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PROGRESS AND POVERTY.

By C. M. LUNGREN.

THE most obvious fact in the industrial life of to-day is the enormous increase of productive power over that of any previous period. Steam and electricity have transformed civilization, endowed us with vaster powers, and altered profoundly the conditions of life. Things that could not have been done at all, things that could only have been done slowly and laboriously by unaided human exertion, have been done with swiftness, exactness, and certainty by the agencies created by human thought and skill. Things that were among the undreamed possibilities are now among the commonplaces of our lives. Machinery, dividing labor to an almost infinite degree, has multiplied its effectiveness manifold. The railroad and the telegraph, bringing men into closer and more intimate relations, have incalculably facilitated exchange. As a result of this greatly enhanced power of production, the accumulation of wealth has gone on at an unexampled rate. Enterprises, however great, need no longer fail for lack of the requisite capital. Works can now be undertaken that in a former age would have seemed and would have been utterly chimerical. We no longer feel that it would be useless to invent railroads because of the immense capital needed to build them.

With this increase of wealth and productive power great ameliorations have been expected. It has been the guiding and dominant faith of this era of remarkable material progress that these new agencies would steadily tend to lift all classes to a plane of greater material comfort. With productive power outrunning consuming power, there would be enough for all. Wealth would become equalized, so that each would receive a share of that produced proportional to his contribution to the common stock. The chasm between the very rich and

the very poor would be bridged. Human powers, no longer the slaves of material needs, would have room to grow; human life, relieved of want and the fear of want, could expand indefinitely in grace and beauty. With time, however, this faith, if not shattered, has been weakened. Improvement has followed improvement, but it has not become easier to make a living; the difficulty rather increases. Wealth has shown no tendency to become diffused, but rather one to aggregate into comparatively few hands. In spite of all this wonderful advance, wages tend steadily to a minimum; and to the lowest class of society—the class that is just able to live—there is little promise of better things.

With the growth of industrial organization in complexity and variety, the increasing strife between employers and employed, the frequent recurrence of periods of business depression, which exhibit in an exaggerated form simply the ordinary conditions of industrial life, the question of the right relation of labor and capital to each other and to the industrial fabric presses with increasing strength for an answer. Employer and employed alike feel that there must be something amiss in an industrial system in which, with want unsatisfied, labor can find no employment and production no market; in which, with increase of productive power, poverty finds no abatement. And the importance of the question is in proportion to its persistence. Beside it all other questions sink into comparative insignificance. For all other progress is inextricably bound up with that of material welfare. It is idle to expect the growth of better conduct or of higher feelings in the man whom want stares in the face. Purer surroundings, better food, greater comforts, some relief from unremitting toil—these are the essential conditions of an improved life. Why poverty persists is the fundamental social question of our time, and must be of all times, until it receives a complete and satisfactory answer.

A thorough consideration has recently been made of this question, and a remarkable answer returned—an answer that finds the solution of the problem in a direction where most people would least expect to find it. In "Progress and Poverty" Mr. Henry George has made a careful and systematic inquiry into the conditions of the production and distribution of wealth, the relations of labor and capital, and has traced out the action of what he considers the cause of the continued association of poverty with advancing wealth. However unpalatable its conclusions to certain large classes of the community, this book must, from its clearness of statement, ingenuity of argument, its large human sympathy, and the broad and philosophic spirit with which the question is treated, claim the attention of all who realize the paramount importance of the subject and the value of a thoughtful contribution toward its elucidation.

Mr. George holds that the causes which determine the persistence of poverty are a part of those which produce progress, and not extra-

neous forces which progress tends to overcome. In support of this he points out certain facts which, though frequently noted, have received a different interpretation. "When the conditions," he says, "to which material progress everywhere tends are most fully realized —that is to say, where population is densest, wealth greatest, and the machinery of production and exchange most highly developed—we find the deepest poverty, the sharpest struggle for existence, and the most enforced idleness. It is to the newer countries—that is, to the countries where material progress is yet in its earlier stages—that laborers emigrate in search of higher wages, and capital flows in search of higher interest." It is here that, "though you will find an absence of wealth and all its concomitants, you will find no beggars. There is no luxury, but there is no destitution. No one makes an easy living, nor a very good living; but every one *can* make a living, and no one able and willing to work is oppressed by the fear of want." Such facts, Mr. George thinks, justify the belief that somewhere in the industrial fabric there must be a fundamental wrong—a social maladjustment that with increasing force, as progress proceeds, tends to continue and deepen poverty.

His inquiry, in which he has taken nothing for granted, but has examined anew all the doctrines of our current political economy, has led him to the conclusion that the primary cause of the low returns to labor and capital is to be found in the private ownership of the land of the earth, which is by right the common heritage of all. He rejects the common notion that there is an antagonism between labor and capital, and holds, on the contrary, that they are both robbed of their full earnings by the landholder. Labor can only produce wealth by having access to the materials it is to fashion, all of which are drawn from the earth, and by having such opportunities to occupy the land as its needs require. Whoever, then, can claim a right to the land can name the conditions upon which these materials can be obtained and this occupation allowed. Whoever commands the land commands the fruits of labor spent upon the land. Before labor can exert itself it must ask permission, and the price of this permission is the tax that, acting with accelerating power as civilization goes on, denies to labor and capital their rightful share in the wealth they have produced.

In claiming that private property in land is a wrong, Mr. George is not alone. He has with him the best thought of all times. Nearly every economist and social thinker of eminence who has made an investigation into the basis of property has found no warrant for the private ownership of land. They have all seen that a natural agent, which is necessary to human existence, and which can neither be increased nor decreased by human exertion, can by no process whatever become the rightful property of one man or any number of men, save all men. And most have seen that to finally settle on an equitable basis this question of the ownership of land will be, as Mr. Spencer

says, "one of the most intricate problems society will one day have to solve." But though the inequity of private property in land has been so generally seen, and though it has also been seen that grave practical injury must result from such a wrong, no one, so far as I know, has before attempted to follow out the effects of this wrong in all the ramifications of industrial society. To understand in any way adequately Mr. George's position, the arguments which support his conclusions, and the facts which he has brought to bear upon the question, a study of his book is necessary; but some idea may be gained of the character of his inquiry, though none of his interesting and graphic treatment, by such an outline as can be here given.

Land and labor are the two factors from whose union springs all wealth. Land is the storehouse of all materials, and the place on which all labor must be exerted. Labor is the force which unceasingly shapes these materials into forms suited to human use. Between these two factors all the wealth created must be divided. Labor may, however, be separated into two forms, past and present, or capital and labor. The division of wealth, then, is between land, capital, and labor. The respective shares of these factors are rent, interest, and wages.

Before proceeding it will be necessary to determine the meaning Mr. George attaches to some economic terms used. In an economic sense labor is all human exertion in the production of wealth. Wages is the return made to this exertion. The payment received by the hired laborer, the clerk, or the professional man, the game of the hunter or the gold of the gold-digger, are equally wages. The kind of work done, or whether the work is done for one's self or for some one else, does not affect the character of the compensation. Whatever is recompense for exertion is wages. As to the meaning of capital, economists are not so well agreed. Mr. George defines it as "that part of wealth used to obtain more wealth"—the part in the hands of the producer to be devoted to productive uses. The term "wealth" Mr. George confines to those things whose destruction would decrease and whose increase would augment the aggregate possessions of a community. Bonds, mortgages, etc., when they are between the members of a community, are not, in this sense, wealth. By land is to be understood all natural capabilities, which are a gift to man. It includes fertile fields, ore-deposits, water-powers, the air, the sea, etc. Rent is the compensation received by the owner of any of these natural capabilities for their use. In ordinary speech the term is used to express the return for the use of some of the products of labor and capital, such as houses, improvements made on land, machinery, etc., but as used in economics it excludes the return made for any of these things. Return for the use of such things is properly interest on capital; return for the use of those things freely given by Nature to man is alone rent.

"The cause," says Mr. George, "which produces poverty in the midst of advancing wealth is evidently the cause which exhibits itself in the tendency, everywhere recognized, of wages to a minimum." The inquiry can therefore be put in the form, "Why, in spite of increase in productive power, do wages tend to a minimum, which will give but a bare living?" The answer given to this question by economic science has been the wage-fund theory. This theory holds that wages are determined by the ratio of the number of laborers to the capital devoted to their employment. As capital is the result of saving, industry can proceed no faster than this saving is effected. The wage-fund remaining the same, any increase in the number of laborers means a decrease in the share of each, and the reverse. The increase in the number of laborers constantly tends to overtake and surpass the increase in capital, and hence wages steadily tend to the minimum upon which laborers will consent to live and reproduce. The theory in this form is now pretty generally abandoned, but, as it is still held that wages are advanced out of capital, Mr. George considers that the abandonment is more nominal than real. On the contrary, he holds that wages are never advanced out of capital, but are drawn from the product of the labor for which they are paid. Labor creates wealth, and it is not until this wealth is created that labor receives its wages. The stock of capital on hand is never diminished by having to be paid for labor, but labor, as it goes along, creates the stock from which it is paid. Of the facts out of agreement with the wage-fund theory one of the most obvious is, that wages and interest do not vary inversely. By the theory, wages should be high where capital is abundant, and low where capital is scarce. The very reverse, says Mr. George, is true. Wages and interest rise and fall together. Labor moves for higher wages where capital flows for higher interest. Wages are high in new countries where capital is scarce, and low in old ones where it is abundant. This fact is generally noted by economists, but it is explained by them as due to the relatively greater production of wealth in new than in old countries. This, Mr. George holds, is demonstrably untrue.

The wage-fund theory also teaches that labor engaged in production is maintained out of present capital—that is, that present labor is subsisted on the product of past labor. This, Mr. George holds, is as baseless as the doctrine that wages are paid out of capital. He maintains that it is not at all necessary that there should have been a previous production of wealth sufficient to maintain the laborer. "It is only necessary," he says, "that there should be, somewhere within the circle of exchange, a contemporaneous production of sufficient subsistence for the laborer, and a willingness to exchange this subsistence for the thing on which labor is being bestowed." A government, when undertaking a work of years, does not collect a stock sufficient to support the laborers until the completion of the

work, but it appropriates the subsistence necessary from present and future production, taking it in the form of taxation. No part of the world really lives on past production—that is, out of the savings of past labor. The whole world really lives from hand to mouth. Let the entire production of any great city be stopped for a day, and it would become evident how entirely men are dependent upon present production. The worker, therefore, on any prolonged enterprise does not draw his subsistence from past labor. He simply draws from the present amount of wealth a certain part in one form after he has added to present wealth a certain amount in another form. "The series of exchanges which unite production and consumption may be likened," says Mr. George, "to a curved pipe filled with water. If a quantity of water is poured in at one end, a like quantity is released at the other. It is not identically the same water, but is its equivalent. And so they who do the work of production put in as they take out—they receive in subsistence and wages but the produce of their labor."

Capital, then, neither pays the wages of labor nor subsists laborers in production, yet it has a function in production. This function is, holds Mr. George, to assist labor by providing it with better tools; by enabling labor to avail itself of the reproductive force of nature, as to get corn by sowing it, etc.; by allowing the greater division of labor, and thus vastly increasing its efficiency; and by holding and distributing the results of labor through exchange. To make exchange perfect there must constantly be great stores of goods in warehouses, ships, and railroad trains—goods held to supply the market, and goods on their way to market. To make labor effective, there must be many and various tools, factories, engines—all sorts of machinery. These tools and these goods in the hands of the producer are capital. Capital may limit the form and productiveness of industry by not supplying these tools or not rendering it this service in exchange, but to do this is a vastly different thing from limiting the exertion of labor, which is what the current doctrine teaches.

The wage-fund theory of the relations of capital and labor thus proves upon analysis to be untenable. The theory is and has always been weak. It has gained its ascendancy and almost universal acceptance, not from its own strength, Mr. George thinks, but from other considerations. Behind this theory stands another theory, that offers an explanation of continued poverty, and that fits into the other so as to lend it support in all directions. This theory is the Malthusian doctrine of population. This doctrine is, that population tends to increase faster than the means of obtaining food. Population presses with greater and greater force against the limit of subsistence. The limit is not a fixed but an elastic one, and the pressure exhibits itself in an increasing difficulty in procuring a living, and in that degree of want that will always keep population within the bounds of subsist-

ence. How this and the wage-fund theory mutually support each other is evident. "According to the current doctrine of wages," says Mr. George, "wages fall as increase in the number of laborers necessitates a more minute division of capital; according to the Malthusian theory, poverty appears as increase in population necessitates the more minute division of subsistence. It requires but the identification of capital with subsistence and number of laborers with population to make the two propositions as identical formally as they are substantially." Mr. George does not deny that the capacity of the earth to support life is limited, and that there are, therefore, bounds to the population that can exist, but he does deny that there is any tendency of population to outrun subsistence, or that there has ever been any historic instance of a people unable to continue from such a cause.

In support of this view Mr. George reviews the condition of China, India, and Ireland, to find that in none of them population has yet pressed upon the means of subsistence so as to decrease the relative production of food, or to increase poverty, vice, misery, and crime. The lower animals, indeed, may press against the limits of subsistence. They can only take such food as can be found. With man the case is widely different. By breeding he can take advantage of the greater rate of reproduction of the lower animals and of the reproductive rate of plants. His powers of producing food may be indefinitely expanded, while his rate of reproduction is in the course of civilization not increasing. Historically the doctrine is not found to be true, and it is not consonant with many of the facts of observation. The essence of the doctrine of Malthus is, that the power of producing wealth does not keep pace with population—that in a dense population the power of producing wealth is proportionately less than in a sparse one. It may be objected that "the power of producing wealth" should read "the power of producing food." But, so long as the *whole* earth can supply enough food for the whole of its inhabitants, the power of producing wealth in any community is equivalent to the power of producing food, because, in consequence of a multitude of exchanges, wealth commands food. That a dense population produces less wealth per member than a sparse one is glaringly at variance with the facts. It is in the very densest population that this power increases enormously in proportion to the number of people. It is to effect this result that all the labor-saving machines exist and all the appliances of exchange have been called into being.

The Malthusian doctrine of population and the wage-fund theory of the relations of labor and capital being disproved, the ground is cleared for a consideration of what their true relations are.

As before stated, all wealth produced must be divided between three things—land, labor, and capital. The shares of these factors in production must stand in some relation with each other, such that two of them being given the other is determined, or that, one being given,

the joint share of the other two is determined. In current economic doctrine there is no correlation between the laws determining the shares of these factors, and the nomenclature does not clearly or correctly express the shares into which wealth is divided. It is common for economists to speak of the division into rent, wages, and profits.

Rent clearly expresses the return made to landholders for the use of the land, and wages the return made for exertion of whatever kind; but profits does not express the return made for the use of capital. It includes, as well, that return made for labor in guiding and directing a business, commonly spoken of as the "wages of superintendence," and also the return for risk of capital. Wages of superintendence properly belong under wages, and, considering the entire field of industry, risk is eliminated. There is then left interest, which expresses all and no more that is properly the return made for the use of capital. The division of the produce is, therefore, into rent, wages, and interest. The laws of each of these will be found to correlate, and this interdependence is presumptive of their truth.

What, then, is the law of wages? In a primitive state of society, or in any of those simple occupations where a man works for himself, without calling in the use of capital, the whole result of his labor constitutes his return—his wages. The man who picks berries, hunts, or fishes, evidently has the berries picked, the game obtained, and the fish caught as the reward of his exertion. The wages of any number of laborers would be the whole amount produced, and the share of each would be proportional to the amount his labor contributed to the general stock of produce. But labor can not proceed very far before tools become necessary. Instead of all the labor being devoted to the things that are desired for consumption, part of the labor must be devoted to making tools that will facilitate the production of the things desired. These tools are capital, and the whole produce now obtained by the joint action of labor and capital will not go to labor alone, but will be divided between the two. Mr. George holds that interest is due simply to the value that the vital or reproductive forces of nature give to the element of time, the return for capital in any form being averaged with the return to capital in those forms in which these forces come into play. The constant tendency is to an equation between interest and wages, so that the return to capital and labor will be the same for the same work done. Labor and capital, therefore, would divide up between them the entire produce resulting from their union, each having a share proportionate to its contribution to the whole. But they are not permitted to make such division. A third party claims a share—the landholder.

If one man owned all the land that was open to capital and labor, he would have absolute control over the produce of these agents. He could take, if his authority were respected, any part of it, or all of it, as he was inclined. In actual industrial society, however, land is in

too many hands to enable the owners to get whatever share of the produce they please. Competition determines the rate at which different lands will rent. The law, which in a condition of free competition determines this share of the landholder, is known as the law of rent. Though not first stated, it was first prominently brought forward by Ricardo. As formulated by him, it has been accepted by every economist of position since his time, and is one of the few doctrines of current economics that in the conflict of opinion have remained unshaken. Mr. George regards it as axiomatic, the terms having only to be correctly apprehended in order to meet with acceptance. This law is that the rent of land is determined by the excess of produce over that amount which the same application of labor and capital will obtain from the least productive land in use. The returns to capital and labor do not depend solely upon the amount and effectiveness of each, but they also depend upon the productiveness of the land upon which they are applied. When lands of different degrees of productiveness are open to them, they will apply themselves to the most productive, and their return will be the entire produce resulting. As land less and less productive remains open to them, the amount that they can produce on it decreases. Hence, on account of the competition for the more productive lands, land-owners are able to appropriate to themselves all of the produce obtained above that which the same labor and capital can obtain from the least productive land in use—the most productive free to them. The law, of course, applies to all lands used for any purpose whatever, though in the current statement of it too exclusive attention is generally paid to its relation to agriculture.

The relations of the shares of the three factors in production may be shown more clearly in the form of an equation: Produce = rent + wages + interest, or produce − rent = wages + interest. How rent affects industry is now evident. The laws of both interest and wages appear as corollaries of this law of rent. For this law states that, no matter what the productive power of labor and capital, these two agents can only receive in wages and interest that part of the produce that they could have obtained on land free to them. The reward of labor and capital does not depend upon what they have produced, but upon what is left after rent is taken out. "The moment," says Mr. George, "this simple relation is recognized, a flood of light streams in upon what was before inexplicable, and seemingly discordant facts range themselves under an obvious law. The increase of rent which goes on in progressive countries is at once seen to be the key which explains why wages and interest fail to increase with increase of productive power. . . . When production increases, as it is increasing in all progressive countries, wages and interest will be affected, not by the increase, but by the manner in which rent is affected. If the value of land increases proportionally, all the increased production will be swallowed up by

rent, and wages and interest remain as before. If the value of land increases in greater ratio than productive power, rent will swallow up even more than the increase; and, while the produce of labor and capital will be much larger, wages and interest will fall. It is only when the value of land fails to increase as rapidly as productive power that wages and interest can increase with the increase in productive power."

The conclusion reached by Mr. George as to the laws which govern the distribution of wealth may now be stated in such form as to show their relation to each other, and to contrast them with the laws as taught by current economics. According to Mr. George—

"Rent depends on the margin of cultivation, rising as it falls, and falling as it rises.

"Wages depend on the margin of cultivation, falling as it falls, and rising as it rises.

"Interest (its ratio with wages being fixed by the net power of increase which attaches to capital) depends on the margin of cultivation, falling as it falls, and rising as it rises."

As taught by the economists, rent is the same.

"Wages depend upon the ratio between the number of laborers and the amount of capital devoted to their employment.

"Interest depends upon the equation between the supply of and demand for capital; or, as is stated of profits, upon wages (or the cost of labor) rising as wages fall, and falling as wages rise." The wide difference between the two sets of laws thus contrasted is evident. In the laws as generally taught there is no mutual relation by which they are all bound in a single whole. As stated by Mr. George, on the contrary, they all correlate with each other, and form a complete whole.

The conclusions embodied in these laws are: That, where land is free, labor when unassisted by capital will take the whole produce; that where it is assisted by capital it will take the whole, less the amount necessary to induce the storing up of labor as capital; where part of the land is appropriated, labor and capital will receive what is left of the produce after the deduction of rent, or what they could have produced on land free to them; when all land is appropriated, the return to labor and capital can be forced to the limit on which these factors will consent to reproduce. This being the relation between the three factors in production, it remains only to see the manner in which increase in population and improvement of the arts affect rent, to understand the full effect of the force that presses so continuously upon industry.

While Mr. George allows the effect that increasing population would have in increasing rent by lowering the margin of cultivation, he yet thinks that this is not the main way in which it affects rent. As population increases in any community, certain land—land at the center of trade and production—acquires new powers, an increased

productiveness. Labor spent on this land can produce results not only vastly greater than it could on land beyond the boundaries of this population, but results that it could not produce at all beyond those boundaries. As the village grows into the city, the nearness of men to each other, the division of labor that becomes possible, the greater economies that follow in consequence, the immense facilities of exchange, increase the effectiveness of labor exerted in the center of population enormously. Here is the market to buy and sell; here the services of the professional man, the tradesman, of any and everybody, become of much greater value to them than they could possibly be elsewhere. Instead of a few men working over a piece of ground, here are multitudes of men to the acre, on floors one above another, producing vastly more than the same number could over a wider area. All these advantages adhere to the land—to this particular land in the center of industry, and these advantages have to be paid for. By the law of rent, all the produce resulting from this increased effectiveness of labor and ease of exchange—that is, more than what the same labor and capital could procure on land free to them—goes to the landholder. Population, then, as it becomes dense, enormously increases rent.

And the increase of improvements in the arts affects rent in the same way. All labor-saving machines can affect production in one of two ways. Production may remain the same, and a certain amount of labor be set free, or the same amount of labor may be used, and production be increased. In an active civilization like ours, the main effect will be in the latter way. For, by the conditions of industry, labor can not take advantage of its increased effectiveness by resting, but must press for employment, and hence the effect of labor-saving devices will be to increase the wealth produced. But to the production of wealth land is necessary, hence the demand for land must constantly increase, steadily forcing down the margin of cultivation. Thus, without any augmentation of the population, rent is advanced.

In the speculative rise in the value of land, there is a further force acting in the same direction as these others. In every growing community there is a confidence that land will increase in value, which leads to the holding of land for such increase. This speculative rise in the value of land shows itself in higher rents.

In this speculative increase of land-values, Mr. George finds the *primary* cause of those periodic depressions of industry which we term "hard times." The essential feature of such a period is the circumstance of numbers of men, able and willing to work, seeking employment vainly; great masses of capital lying idle; quantities of goods in warehouses and stores unsalable. It is not that productive power has been too active; it is not that consumption has been too great. The over-production and over-consumption theories have never been satisfactory. Economists have seen that, as the very object of industry is to produce wealth, there can never be too much

wealth, and men generally have seen that the desire for consumption is not lessened. They have all felt that the difficulty lay rather with a choking of exchange. There has been a hitch somewhere by which production and consumption could not meet and satisfy each other. Looked at closely, an industrial crisis always reveals the fact that there has somewhere been a check to production. These producers stopping, their demand for the things they consume ceases, and the check is thus rapidly propagated throughout the entire industrial organization, cessation of demand resulting in cessation of supply, and this in turn manifesting itself in a new cessation of demand. It is not necessary that production be really less, but only less relatively. In an advancing community, the failure of production to increase proportionally would have the same effect as decreasing production in a stationary one. How, then, is this check in production brought about? If we trace it from one point to another, we shall ultimately find it in some obstacle which checks the expenditure of labor on land. The speculative advance in rent crowds down wages and interest to the point at which they will no longer consent to reproduce, production ceases, and the effects of this stoppage are propagated throughout the entire framework of industry. Deduction from the law of rent shows that unchecked rise in rent must show itself in an industrial crisis, and the facts, he holds, abundantly support the deduction. Production may be likened to a steam-engine and rent to its governor. A lightened load, an increased pressure, and the engine bounds forward with accelerating speed. But the power that drives the engine drives also the governor; the force that has doubled the speed is the force that must ultimately check it—the governor, overtaking the engine, throttles the power that gives it action. And so in endless repetition.

Here, then, is the explanation of the facts that mystify and perplex whoever considers them. Here, then, in the relation of rent to wages and interest is the primary cause of the failure of invention and discovery to benefit the workingman. Wages and interest steadily tend to a minimum, but the incontestable fact in material progress is the rise in land-values. The great machinery of modern industry does not benefit labor and capital, because it does benefit the landholder. So long as men can control the land which all must use, they can command all the fruits of labor above what is necessary to a bare living.

"Everywhere, in all times, among all peoples," says Mr. George, "the possession of land is the base of aristocracy, the foundation of great fortunes, the source of power. As said the Brahmans ages ago—'To whomsoever the soil at any time belongs, to him belong the fruits of it. White parasols and elephants made with pride are the flowers of a grant of land.'"

Mr. George does not think that he can be said to have advanced any theory, but that he has only pointed out the most obvious rela-

tions. Taking the accepted law of rent, he has only insisted that, where the whole produce is between three factors, the law that determines the share of one *must* necessarily give the share of the other two. He has only pointed out that, if rent takes all above a certain amount, wages and interest can't have more than this amount.

The fact that the laws of wages, interest, and rent must be mutually dependent, Mr. George thinks so evident, that he marvels that so many acute thinkers could have failed to grasp the proper relations. He is even tempted to believe that some have seen, but, seeing also the enormous consequences, have turned away, remembering that "a great truth to an age which has rejected and trampled on it is not a word of peace, but a sword!"

In finding the cause of the persistence of poverty in the continuous advance of rent, the remedy is at the same time found, and Mr. George does not hesitate to apply it. He would make land common property. He reviews all the remedies proposed and finds none save this sufficient. No alleviation would follow from a decrease of the expenses of government, as this would be equivalent to an increased production, of which the landholder would take all the gain. Education and habits of industry can increase the laborer's share in production to only a very limited extent. Such qualities are like speed in a horse—it is only available in so far as it exceeds that of its competitors. Better material condition, it is true, is usually associated with the possession of such qualities, but the condition is the cause of them and not they of the condition. Little, likewise, can be expected of combinations of workmen. They can, indeed, increase their wages by such means, and not at the expense of each other or of capital as is commonly supposed, but at the expense of rent; but they can do so in so small a degree that the effect is relatively unimportant. In any contest between employers and employed it is not a struggle between labor and capital, but between labor and the owners of land, and it must always be an unequal one. Such a contest is, moreover, a destructive one—a war which, like any other, lessens wealth. And the organization for such a war, as for any other, must be tyrannical. Contests of this sort are, therefore, destructive of the very things sought to be gained by them —"wealth and freedom."

The hopes of those who see in coöperation the instrument of industrial regeneration seem to Mr. George doomed to perpetual disappointment so long as land remains appropriated. If coöperation has any power at all, it is one analogous to an improved instrument of production, which can increase the amount produced, but can not augment the laborer's share in this amount. Governmental direction and interference can only, in the present state of industry, be mischievous and inefficient.

The remedy most counted on, by those who have seen, in a vague way, that there is some connection between industrial distress and land

tenure, is the dividing the land up into small holdings. Mr. George thinks this both impracticable and undesirable, as well as inefficient. Land can not be so divided, and even if it could, it is against those tendencies that are born of and grow with civilization. Machinery applied to agriculture makes cultivation on a large scale more economical than on a small one, and such holdings would interfere with the most advantageous occupancy of the land. The plan, however, has the cardinal objection that, unless every member of a community was a holder of land of equal productiveness, it would not abolish rent, and would therefore have no tendency toward an equitable division of the produce. There therefore remains only the plan of giving to every one equal rights to the whole land—the plan of making land common property.

Mr. George dismisses the claim of the landowners to compensation. If they were paid the market price for the land, industry would not be relieved, as the tax would remain in the form of interest on the purchase-money. Such an arrangement would, of course, prevent the further tax upon industry caused by the future increase of rent, but still the main burden would remain. Injustice, Mr. George thinks, has and can have no vested rights. If it be a wrong to deprive the landowners of their land without compensation, it is a greater wrong to take from industry to pay them for a value that industry has alone created. It is a conflict of claims, and the lesser claim must be the one disregarded. He points out that, tried by the common law, which through all the ages has been built up and elaborated by the dominant class, the landholders, they would not only get no recompense for their land, but none for their improvements; and, further, that they would be called to account for the returns received during the time the land was held. Mr. George is, however, satisfied to waive this, and be content with the resumption of the land by society.

In carrying out his project of making land common property, Mr. George would disturb as little as possible existing industrial, social, and political organization. He does not think that it is either necessary or desirable to effect his purpose directly. It can be done better and with less shock to accustomed feelings and habits, and with greater economy of means, indirectly. His plan is very simple. He would place *all* taxes upon land. He would leave the titles to land in the hands of individuals to buy and sell, to let and hold the same as now, but while leaving the shell he would take the kernel, by confiscating rent. We now take some rent in taxation; he would take it all. This would pay all government expenses, and would increase rapidly enough to meet them as they increase, and to perhaps leave a surplus. Such an arrangement would result in an enormous simplification of government. It would take no more labor to collect land-taxes then than now, while all the cumbrous institutions now in use—custom-houses, internal revenue service, etc.—with their vast and demoralizing influence on political life and their prodigal waste, would be abolished.

Land can not be hid; its rent at any time is readily ascertainable, so that the Government would get a considerably larger percentage of taxation than now.

Mr. George tests his proposition by the accepted canons of taxation, and finds that the tax on land is the only tax which can not be distributed—which those taxed can not throw off on to others. It is, therefore, the only tax which does not bear upon production. This also follows from the law of rent, as the relation between the most productive and least productive land in use is not altered by such a tax, and therefore the share of labor and capital can not be affected by it. Under such tenure of land the burden of taxation will be raised from production, and, while it still pays rent, though a greatly reduced one, this goes to the state, to be used for the benefit of those who have created the fund.

Under such an arrangement, land would be improved as fast as there was a demand for it. No one, as now, could afford to hold land unless he proposed to use it. There would be no prospect of parting with it at a future time for more than now, while the holder would have to pay an increasing rent without any advantage accruing to him. This tax, therefore, would have the effect of forcing improvement instead of acting, as present taxation does, as a fine upon improvement. Nor need any fears be entertained that such a holding of land would deter men from improving it because they did not own it. Ownership is not necessary, as is shown by the many costly buildings in every city built upon leased land. All that is necessary is that there be security for the improvement.

Mr. George holds that, though the proposal to place all taxes on land is, at first sight, to increase the burdens of the farmer, it is not in reality so. At present he is taxed on all his improvements, houses, barns, fences, stock, and crops, while, through the action of the tariff, he pays enormous taxes on everything he consumes. Under the arrangement proposed all these taxes would be removed, and there would remain only the tax on the bare land. As speculative land-values would be abolished, and large tracts of land now held thrown open to improvement, the value of his land would decrease, with the result that, in sparsely settled districts, he would have little or no taxes to pay. The tendency of this measure would be to distribute population more equitably—to take from the overcrowded city and add to the thinly settled country. With the continued application of machinery to agriculture, farming life would tend to assume the form of the village community, whence the great gain to the farmer in the increased advantage of social intercourse. He would lose little or nothing in a pecuniary way, and gain much in an improved social life. And so with the owners of homesteads, and all land-owners whose interests as such do not greatly predominate over their interests as laborers and capitalists.

Of the effect of his remedy upon the material, social, and moral welfare of society Mr. George is very hopeful. Under its action he sees production bounding forward with giant strides; the great agencies, which man has called into being to help him subdue the earth, no longer of doubtful good. By the power of these "slaves of the lamp of knowledge" he sees wealth increased on every hand, and distributed to each according to his labor. He sees these great forces elevating society from its very foundations. Each would have enough and to spare. Men would no longer seek vainly for the opportunities to labor. Competition would no longer be one-sided. "Into the labor market would have entered the greatest of all competitors for the employment of labor, a competitor whose demand can not be satisfied until want is satisfied—the demand of labor itself." All raised above want and the fear of want, human life would expand in new directions and under the impulse of new ideals. The worship of wealth is but the expression of the fear of want. All men struggle to place themselves above want and the possibility of it. What men struggle for they admire, and to win the admiration and approbation of their fellows, if not the strongest, is at least one of the strongest, passions of human nature. With the passing away of this fear of want, however, will come a declining admiration of wealth, self-seeking diminish, seeking the good of others increase. And there need be no fear that, with declining need to devote his powers to getting subsistence, man will stagnate. "Man is the unsatisfied animal." For him are all the powers of the heavens and the earth. Beyond material needs there are spiritual needs.

That love of knowledge which has given us our sciences, of the beautiful which has given us our art and literature, will in the future as in the past appeal to and excite our highest powers. Whatever may have been the need of the stimulus given by the fear of want, it no longer exists. Humanity now needs but to be assured of the fruits of its labor to go upon the heights. It needs but this to realize the dream born of material progress—to make for itself the golden age:

"Youth no longer stunted and starved; age no longer harried by avarice; the child at play with the tiger; the man with the muck-rake drinking in the glory of the stars! Foul things fled, fierce things tame, discord turned to harmony! For how could there be greed where all had enough? How could the vice, the crime, the ignorance, the brutality, that spring from poverty and the fear of poverty, exist where poverty had vanished? Who should crouch where all were freemen; who oppress where all were peers?"

Such the promise Mr. George holds out to society if it but consent to "render unto Cæsar the things that are Cæsar's"—to give to labor and capital their reward. If it consent not, he raises his voice to warn it that it must crush the worm that is gnawing at its vitals, if it be not destroyed. If labor get not its reward, the gulf between the

rich and poor must widen as material progress goes on; the mass of ignorance, of brutality, of recklessness, the number of those who are in our civilization but not of it, must increase and threaten its existence. The barbarians who will destroy our civilization come not from without but from within. "In the shadow of college and library and museum are gathering the more hideous Huns and fiercer Vandals of whom Macaulay prophesied."

Mr. George closes his book with a theory of progress in which heredity counts but little, and conditions much; whose law is association in equality. Men advance as they come in closer contact, and as the conditions of each are more nearly equal; and fail to do so or decline as these requirements are not met. Civilizations rise and fall, stop or turn back, or are transformed in obedience to this law.

I am not here concerned with criticising Mr. George's work, with pointing out the extravagance of his expectations; the fact that human nature is not nearly as easily modified as he assumes; that poverty is but one of the factors in the production of vice, misery, and crime; that far-reaching biological and psychological laws are not so readily set aside as he seems to think. These things do not affect the essential doctrine of his book—that, by the law of rent, rent must have a determining influence in the distribution of wealth. My purpose is served if I have succeeded in drawing attention to what seems to me one of the most important contributions yet made to economic literature.

WHAT IS JUPITER DOING?

By HENRY J. SLACK.

THE question, so often suggested by changes in the aspect of the planet Jupiter, "What is he doing?" is again forcibly put by the appearance of a remarkable spot of enormous dimensions, and of a reddish or orange-brown tint, which has occupied the attention of observers for several months, and which seems to be identified, so far as relates to position and form, though not in color, with what has been seen on former occasions.

Probably no celestial bodies reach a permanent condition: constant change seems a law of nature; but there may be great variations in the rates at which changes occur. If we assume as probable a modification of the nebular theory, suns and their attendant planets are formed by the condensation of matter in an extreme state of tenuity, and the mass of suns and planets may receive frequent additions in the shape of any smaller or less heavy bodies they are able to attract. Our sun is probably a great devourer of meteors; and, as our earth

crosses the orbits of certain meteoric swarms, we have showers of shooting stars, fortunately so small that their bombardment is unnoticed.

Scarcely anything is known, or plausibly guessed, concerning the condition and properties of nebulous matter. If, for example, the

FIG. 1.—SPOTS ON JUPITER OBSERVED AND DRAWN BY MR. E. L. TROUVELOT.—Observation of September 25, 1878, with the shadow of a satellite.

spectrum of a nebula indicates hydrogen, we may be pretty sure it is not in the state of the gas as it is known in our laboratories. The recent discoveries of Crookes concerning the properties of matter a million times more attenuated than common air lead to the hope that fresh light may be thrown upon many astronomical questions; but in the mean time it is impossible to form more than a vague idea of the condition of any star or planet that does not in its main features resemble our earth; and this can be said only of Mars, on whose globe we can discover what is probably land and what is water, and see white masses, which it is reasonable to believe are snow, form and melt away as the planet's winter and summer affect them in turns.

Our earth has long been in a state of slow, as distinguished from that of rapid, change. The geologist finds the oldest rocks he can discover affording indications that they were formed when the circumstances of the globe were sufficiently like what they are now for fair comparison. The earth's surface may have been warmer, its atmosphere more moist, and it may have contained more carbonic acid than we now find; storms may have been more frequent and more violent, but the assemblage of differences between what now is and what was

at the time of any formation the geologists can reach would not noticeably approach the enormous difference that separates the condition of our earth from that of either Jupiter or Saturn. It is possible that they now represent stages which our earth passed through in remote times, and they may be undergoing changes that are approximating

FIG. 2.—SPOTS ON JUPITER OBSERVED AND DRAWN BY MR. E. L. TROUVELOT.—Observation of December 23, 1878, with the shadow of the third satellite.

them to our present condition. It is, however, probable that, while there are analogies and resemblances in the life-histories of all the heavenly bodies, there are also individual peculiarities and diversities not less important or less striking.

Jupiter's diameter is about eleven times that of our earth, and his mean density is about a quarter that of the earth, or about a third more than water. Now, a bulky body may be composed of heavy materials, and still, as a whole, be light, like an iron ship or a lump of pumice-stone, that will float in water. The pumice-lump is light on account of its vesicular formation, so that the mass consists of heavy feldspathic material and the air it contains. Extract the air, and the pumice loses its floating power, though still far from heavy in proportion to its bulk. Most of the earth's crust is formed of solids much heavier than water. Granites are more than two and a half times heavier than water, slaty rocks much about the same, and so are ordinary limestones, the variations of all being from about 2·5 to 2·9. The ironstone group contains denser minerals; red hematite has a specific gravity of 4·5; magnetic ironstone, 4·5 to 5·2, etc.; and many other ores are heavy.

At some remote period, when only part of the now solid earth had been condensed from gaseous and vapory matter, our planet might have had a mean density like that of Jupiter, as its rocky materials contain between forty and fifty per cent. of oxygen; and while condensations and chemical combinations were going on rapidly our globe must have been the scene of

"Thunders, lightnings, and prodigious storms."

And it is probable that certain stars which have suddenly blazed forth with passing splendor have exhibited to us the spectacle of conflagrations extending over millions and billions of square miles. Color-changes in Jupiter—such as those noticed by Mr. Browning and the writer in 1869–'70—may have been caused by soda-flames, though not fierce enough or extensive enough to add materially to his ordinary luminosity, which is estimated as always exceeding, though not in a very high degree, what it would be by mere reflection of light received from the sun. A drawing after Mr. Browning was published in the fifth volume of the "Student and Intellectual Observer," showing a broad, full, yellow equatorial belt; also broad belts of purplish brown edged with narrower yellow bands above and below it, and curious white patches in the upper dark belt. The polar belts were purplish and olive. The appearance and disappearance of these remarkable belts indicated great physical changes, and it is to be regretted that spectroscopes could not afford so much information as was hoped for. The planet, though appearing much brighter than any star, gives, according to Mr. Browning, a spectrum fainter than that of a star of the second magnitude. It is the size of the planet and his nearness, as compared with the distance of any fixed star, that make him such a brilliant object. The size of a luminous body greatly affects our estimation of the intensity of its light. Mr. Huggins, at the time mentioned, discovered some dark lines in the Jovian spectrum not belonging to the solar spectrum, and probably resulting from the absorptive action of the planet's atmosphere. He also pointed out that the remarkable yellow color had been seen some years before. Quite recently Mr. Huggins has been employing his large reflector to take photographic spectra of the planet, and he informs the writer that "from G to O in the outer violet there is no sensible modification, either in addition or absence of lines, of the solar spectrum." This is curious, as Jupiter has exhibited a good deal of primrose tint, with orange-brown belts and a big orange-brown spot.

A telescopic view of Jupiter usually exhibits some dark belts, occupying a zone of considerable breadth, on either side of the planet's equator, with less conspicuous markings nearer the polar regions. It is also common to find various-shaped patches brighter than the rest. Sometimes the general pattern formed by these markings lasts for months with little visible alteration. At other times a few min-

utes are sufficient for changes of enormous magnitude. The first question that arises is, What do the dark bands or spots mean? Are they portions of the solid body of the planet, which have some fixity of shape, in any degree analogous to that of our mountain-chains or great continents? Or are they cloudy matter of less light-reflecting power than the bright and dense atmosphere by which the planet appears to be surrounded? Or are they merely more transparent parts of that atmosphere, through which no lower objects happen to reflect light enough to be visible? If the bright parts of the Jovian disk are light-reflecting clouds, and the dark belts the body of the planet, we should suppose it would be common to see a notched appearance of the edges; but this is not so. "Ordinarily," as Captain Noble says, "the belts fade perceptibly as they approach the actual edge of the disk; but," he adds, "I *have* seen the belts right up to it." The softening of the belts, as the planet's rotation brings them to the edges of the disk, probably arises from the dark parts being considerably below the boundary of the Jovian atmosphere, and thus seen through a greater thickness of it when near the edges. When the dark belts touch the edge without noticeable softening they must be higher up, and less likely to be any part of the solid body, if Jupiter has anything that can be so called. The great spot of this season has never been seen close to the edge. A very moderate magnification is sufficient to show that as the planet rotates it comes into view decidedly at some distance from the luminous margin, and disappears at a similar distance from the opposite margin.

Telescopes, under the most favorable conditions, and of the greatest power, only reveal very large features of the planet. It is impossible to see anything like details of structure, and this makes the identification of objects seen at different times more or less uncertain. If we had glimpses of great mountain-chains in Jupiter, it would be something like seeing the Andes or the Himalayas all in a lump, from some skyey perch, so far off as to prevent the separate peaks and valleys from being noticed. Jupiter is about five and one fifth times as far from the sun as we are—our mean distance, according to the last reckoning, being 92,620,000 miles. With the moon only 240,000 miles off, and very frequently bearing a much higher magnification than can be applied without confusion to Jupiter, telescopes bring no object near. A magnification of 1,000 linear—only usable under very favorable circumstances—makes lunar objects as big, but not as distinct, as a naked-eye vision of them would do if it could approach within 240 miles. With the enormously greater distance of Jupiter it must be evident how impossible it is for anything but huge masses to be seen.

Jupiter's atmosphere is much larger in proportion to any solid matter he may contain than that of our earth to its solid matter. It is also much denser, and from its greater distance only gets about one twenty-fifth as much solar influence as reaches us. For these and

other reasons it is not unlikely that some of his cloud formations may be more lasting than ours. That his gaseous envelope is, however, at times subject to violent disturbances arising from a prodigious exertion of internal forces is proved by instances of sudden changes in the diameter of the disk. The Rev. T. W. Webb, in his "Celestial Objects," mentions as "inexplicable" an observation of Smyth, confirmed by similar observations of Maclear and Pearson, all being at different places, namely, that on June 26, 1828, Jupiter's second satellite, after fairly entering upon the disk, in the course of its revolution, was subsequently seen for four minutes outside it, and then suddenly vanished. More recently Secchi noticed a similar phenomenon; and the explanation can only be that Jupiter's atmosphere was suddenly blown out for some thousands of miles and retreated again. Secchi states that on April 2, 1874, he watched the first satellite as it was about to cross the planet's disk, which appeared "finely undulated." "When the satellite approached within its own diameter of the margin of the planet the latter sprang toward it, appeared to touch it, and immediately retired. This happened, backward and forward, until the satellite had plainly entered upon the planet; that is to say, for four or five minutes.* . . . The satellite appeared fixed, and all the movement seemed to belong to the disk of the planet."

In October, 1879, Mr. Kidd, of Bramley, Guildford, saw, as is described in the "Observatory" for November, the second satellite first touch the disk, then appear separated from it, and finally pass behind it, but remain for some time visible through it. The "Observatory" for November also quotes the "Chicago Tribune," to the effect that observations at the Dearborn Observatory indicate that changes in the outline of the planet take place from day to day. Two sets of measures at the interval of a week are stated to have shown a difference in the direction of the major axis amounting to 5°.

When extensive belts or bright portions change rapidly, the storm-effects must be immensely greater than in any of our hurricanes. Jupiter's motion at the equator is at the rate of about 28,000 miles an hour; his daily rotation is completed in a few seconds less than ten hours; and objects in Jupiter weigh about two and a half times as much as on our earth. When our winds move with a hurricane-speed of 85 miles an hour, they exert a pressure upon whatever they strike equal to 36 pounds per square foot. What, then, must be the force of a Jovian storm, moving much heavier matter than our air, at the rate of 300 miles an hour, as was observed on one occasion by Herschels?

On another occasion South saw a spot 22,000 miles long, and before a friend who was present could commence a sketch it had nearly all changed. There may in such cases be violent chemical action, a terrific clashing together of atoms, and the precipitation of solid oxides of metals, like the fumes produced by the burning of magnesium wire.

* "Comptes Rendus," 1874, vol. lxxviii., p. 1468.

In considering the persistence of spots or markings, it seems that the dark ones are more lasting than the light. A dark spot noticed by Cassini in 1665 was visible up to 1713, though obscured at intervals—at one time for eight years.

Some interesting white spots were noticed in 1878 by Niesten, of the Brussels Observatory, to change from a circular to an elongated form as they appeared in the center or nearer the sides of the disk. This would indicate something like a columnar form, looking round when seen vertically, and elongated when seen aslant.

Lately, as already mentioned, a very fine dark spot has been seen upon the south equatorial belt. It was found by Niesten to be 13″ long, and 3″ wide, the polar diameter of the planet being 48″. When Captain Noble saw this spot, on August 22, 1879, he made a memorandum that "the remarkable spot sketched on November 19, 1858 (nearly twenty-one years ago), reappears—or one very similar indeed to it does—to-night."

M. Niesten kindly sent to the writer—who published a translation of it in the "Astronomical Register" for November—a list of observations of red spots more or less identical in aspect with this one, and probably of the same formation. It is not to be expected that in the revolutionary state of things existing in Jupiter there would be the same persistence of form that belongs to our islands and continents; and it is quite possible that there may be huge islands of vesicular formation, far bigger than all Australia, floating in viscous seas; so that if the figure of a spot remains the same, or spots seen at different times bear a strong resemblance to each other, they *might* be identical, even though there had been some change of place. Mathematicians tell us that the flattening at the poles noticeable in Jupiter and Saturn, and caused by their rapid rotation, would be greater than measurement shows, if such light bodies were homogeneous. There must, therefore, be some portions much denser than others, and these planets most probably contain matter in all intermediate stages, from the attenuated gaseous, through the viscid, to the solid. It must often happen, as Chacornac considered traceable in the sun, that condensation produces a great down-rush, and substances that have been solidified falling into hotter regions get melted up or vaporized again.

The great red spot lies like a continent some 24,000 miles long, surrounded by a rather narrow sea of light, and over it Niesten noticed two brilliant little spots which he appropriately named "pearls." There is a general concurrence of opinion that the big spot grew ruddier than when it first appeared, or rather richer in color; its "*redness*" has been chiefly caused by the want of achromatism in the telescopes employed. Glass mirrors silvered—which represent colors most correctly—show the tints to be orange-brown. The bright parts, as seen by the writer with a With-Browning silvered mirror and a fine prism, closely resembled the color of autumn beech-leaves in full sun-

light. Some Merz telescopes add, from their defects, a purple tint; and an instrument of another maker gives the spot the color known as Venetian red. Dr. Pigott, who has a With-Browning silvered mirror instrument, and a fine refractor by Wray, finds the latter so unusually well corrected that its performance coincides closely with that of the former. Color-changes, both as regards time and intensity, may be caused by the greater or less translucency and refracting powers of the atmosphere through which any object is seen; but they may also very frequently arise from the greater or less heat and luminosity of solid or viscid matter below the cloudy strata, and from important modifications of chemical action. Between September 3d, at from 10.45 to 10.55 P. M., and October 4th, 10.40 P. M., Captain Noble's drawings, made at Maresfield, show a great change in the aspect of the planet, affecting the brightness and the tint of enormous spaces. Parts above the great spot which were brilliant on the former occasion had become cloudy, and, southeast of the spot, there came a round white spot, with very dark surroundings. These changes must have affected many millions of square miles.

On October 16th, at 10.5 P. M., he noticed the color of the red spot "more marked than ever." There were also extensive changes in the belts, and the polar regions were more cloudy. He made the following entry in his note-book: "It is a most noticeable feature; the red spot reposes like an island in the middle of a light space on the planet's disk, and the belts, north and south of it, seem in a great measure to conform to its curved outline. This would indicate a disturbance of a stupendous character, from the amount of the area involved."

On the whole, during the season for observation of 1879–'80 Jupiter has been more than usually interesting. From pole to pole changes of great magnitude have been produced with prodigality of violence rather than with economy of time. Perhaps the mighty planet is still in the stage of youth, with blazing and explosive energies that a few hundred thousands of years may be required to tame down to the soberness of our comparatively quiescent earth.—*Belgravia.*

[NOTE.—The red spot spoken of above was watched by an astronomer in this country, Mr. E. Leopold Trouvelot, of the observatory at Cambridge, during a part of 1878. He has published an account of his observations in "The Observatory," and has furnished to "La Nature" two views of the spot as seen at times three months apart, which we reproduce. In his published description, Mr. Trouvelot says that in looking at Jupiter on September 25, 1878, at six hours and fifty minutes, he noticed a remarkable red spot a little above the southern border of the equatorial belt, with its center situated a little to the east of the central meridian. It occupied apparently about one fifth of the diameter of the planet, and was quite distinct, its intense rose-color forming a striking contrast with the luminous white ground on which

it was projected. It was of the same shade, uniform from one end to the other, without any obscure border. It appeared isolated and entirely independent of the equatorial belt, from which it was separated by a brilliant white band. In shade, its color was quite different from the pale rose-color of the equatorial belt, and from every other object which the observer had ever seen on Jupiter, and might be described as a blending of vermilion and blue. Fig. 1 is a copy of the original sketch made immediately after the observation, *a a* indicating the red spot. After this observation, the return of the spot was noticed, and it was drawn fifteen times. It was last seen on December 30, 1878, after which further observations were prevented by the proximity of the sun. The form of the spot changed somewhat during this time: at first, it was long and narrow (Fig. 1, *a a*); finally (Fig. 2, *b b*), it became shorter, considerably wider, and extended farther toward the south.—EDITOR.]

THE SCIENTIFIC ASPECT OF "FREE-WILL."

BY ALBERT J. LEFFINGWELL, M. D.

FROM the time when, as Milton tells us, the lost angels

> ". . . . Reasoned high
> Of providence, foreknowledge, will and fate—
> Fixed fate, free-will, foreknowledge absolute"—

no problem has excited greater interest in the human mind than the question of free-will. Philosophy, whether pagan or Christian, atheistic, Catholic, or Protestant, has alike found in its consideration an irresistible attraction; and, if the world remains to-day of divided opinions, it is not for lack of abundant argument. Seneca taught that "the same necessity binds both gods and men; divine as well as human affairs proceed onward in an irresistible stream"; while Pope thought he had solved the problem by imagining a Deity

> "Who, binding Nature fast in fate,
> Left free the human will"—

a flattering conclusion which the world finds it easy to accept. Theology, fearful, on the one hand, of rendering Deity the cause of evil, and, on the other, of limiting his due share in the government of the universe, usually teaches that necessity and free-will are alike true, though not to be reconciled; a conclusion which would render all reasoning on the subject inconsequential if not absurd. Some have thought to retain their favorite theory by so defining it that no difference of opinion can exist; as Dr. Haven, for instance, who, in his

text-book on "Mental Philosophy," postulates that "freedom of will is power to do *as I like*," and that "the will is free when I can will to do just *what I please*"—seemingly unconscious that the whole question is *why* "I like" or why "I please." Others make both free-will and necessity utterly unfathomable mysteries, and then choose between them. Sir William Hamilton, while admitting that freedom of the will is "wholly incomprehensible"; that we "can not conceive a free volition"; that we are "utterly unable speculatively to understand how moral liberty is possible to man or God"—insists, nevertheless, that the doctrine of necessity is equally unthinkable, because we can not conceive an infinite regression of causes to all eternity; and then finds in "our consciousness of an uncompromising law of duty" a decisive proof of free-will. This is certainly to claim for consciousness of duty, as a witness, a superior function to that which it fills as an agent; for if it has proved again and again an unreliable guide to conduct—leading Calvin to burn Servetus, the Inquisition to torture heretics, and the Puritans to hang witches and Quakers—it is not easy to see why so imperfect a guide to action should be of such supreme value as a testimony to freedom of action. Nor is it clear how a Christian philosopher should have found in our consciousness of the moral law an evidence for a "wholly incomprehensible" theory, superior in force to that which the theistic hypothesis supplies to the doctrine of universal causation.

As it stands to-day, the question is very nearly one between science and theology. On the one hand, science asserts that to the law of causation there are no known exceptions; that mind as well as matter is subject to law. Theology, on the contrary, clings to the freedom of volition as the apparent foundation of morality; and insists that each man is a new cause—a new, unconditioned, responsible factor in the conduct of the universe; and this is the view most generally accepted by the world. The reason is not far to seek: it lies in the teaching of theology regarding man's future state. We instinctively feel that, if upon the nature of our actions depends the awful fate of unending happiness or misery in another existence, justice to the creature demands that his liberty be undetermined in any way by the Creator. Now, theology for the past eighteen centuries has taught, as it yet teaches, this doctrine of eternal punishment. While at the present day it is rarely pushed forward into the old-time prominence, it stands in the creed of every orthodox church; it is yet an essential element of Christian faith. Let us look at it for a moment as presented by a theologian, the greatest that America ever produced, the Rev. Jonathan Edwards. The extracts quoted are from the edition of his sermons published in 1879:

You have often seen a spider when thrown into the midst of a fierce fire; and have observed how immediately it yields to the force of the flames, and the fire takes possession of it, and at once it becomes full of fire, and is burned into

a bright coal. Here is a little image of what you will be in hell, except you repent and fly to Christ.—SERMON X.

Do but consider what it is to suffer extreme torment for ever and ever; to suffer it night and day, from one day to another, from one year to another, from one age to another; in pain, in wailing and lamenting, groaning and shrieking and gnashing your teeth; with your bodies and every member full of racking torture; without any possibility of getting ease; without any possibility of moving God to pity by your cries (*sic*). How dismal will it be under these racking torments to know that you never, never shall be delivered from them; to have no hope; when after you have worn out the age of the sun, moon, and stars, without any rest day or night, or one minute's ease, yet you shall have no hope of ever being delivered; you shall know you are not one whit nearer the end of your torments; but the same groans, the same shrieks, the same doleful cries are incessantly to be made by you, and the smoke of your torment shall ascend up for ever and ever; your bodies, which have been burning and roasting all the while in glowing furnaces, yet shall not have been consumed, *but will remain to roast through an eternity yet.*—SERMON XI.

I shall mention several *good* and *important* ends which will be obtained by the eternal punishment of the wicked . . . .

III. The saints will be made more sensible how great their salvation is. When they shall see how great the misery is from which God has saved them, and how great the difference he hath made between their state and the state of others who were by nature, *and perhaps by practice, no more sinful and ill-deserving than they*, it will give them a sense of the wonderfulness of God's grace. . . . The view of the misery of the damned will double the ardor of the love and gratitude of the saints in heaven.

IV. The sight of hell-torments will excite the happiness of the saints for ever; it will make them more sensible of their own happiness; it will give them a more lively relish of it! Oh, it will make them sensible how happy they are!—SERMON XI.

When they shall see how miserable others of their fellow creatures are—when they shall see the smoke of their torment and the raging flames of their burning, and shall hear their shrieks and cries, and consider that they in the mean time are in the most blissful state, and shall surely be in it to all eternity, how they will rejoice! . . . How joyfully they will sing to God and the Lamb when they behold this!—SERMON XIII.

So long as this remains the orthodox view of the fate reserved for a majority of the human race, so long as to doubt the reality of such a Deity is to incur the suspicion of atheism, it will be difficult for men to yield the intellectual figment of "free-will" for the logic of necessity. True, the doctrine of predestination, which teaches that "by the decree of God, and for the manifestation of his glory, some men and angels are predestined unto everlasting life, and others foreordained to everlasting death," still stands in many a creed; but most men do not suspect its existence; it is rarely if ever preached at the present day. Otherwise unable to reconcile eternal torture with an ideal of divine justice, probably the faith of ninety-nine out of every hundred persons is that each human being possesses a perfect liberty of choice, and undetermined volition.

The view of science upon this question is widely different. Of eternal fires, which serve at once to torture the skeptic and heighten the felicity of the saint, it knows nothing; the belief in them belongs rather to those cherished mysteries of faith which lie far beyond its scope. In that functional activity we call mind, it recognizes no power to originate uncaused volition. The universe is subject to law. Nothing ever happens or comes to pass without a cause. The cause determines the event, so that it could not be otherwise. What determines volition? Motives. The will is always determined by the strongest motive.

Given the motives which are present to an individual's mind, and given likewise the character and disposition of the individual, his actions might unerringly be inferred.—JOHN STUART MILL.

The conjunction between motives and voluntary actions is as regular and uniform as that between the cause and effect in any part of Nature.—HUME.

The only meaning of the law of causation in the physical world is, that it generalizes universal experience of the order of that world; and, if experience shows a similar order to obtain among states of consciousness, the law of causation will properly express that order. That such an order exists is acknowledged by every sane man.—HUXLEY.

It is claimed, however, that consciousness asserts itself with decisive force in favor of free-will. Is this true? "I dispute altogether," says Mill, "that we are conscious of being able to act in opposition to the strongest desire or aversion." But this is a point which we are all able to investigate for ourselves. Indeed, the peculiar advantage of metaphysical study is the opportunity universally possessed of testing theory by observation, in watching the operations of our own minds. I propose, therefore, to go directly upon the ground assumed as their own by the advocates of free-will, and rest the proof of causation upon the uniform testimony of consciousness. It seems to me that the evidence in favor of the scientific view is so cumulative and convincing that a reasonable being, capable of comprehending the problem, and unbiased by dogma, could, after its consideration, more easily assert his intangibility than his liberty of volition.

If we define the will as that "by which the mind chooses anything," and an act of the will as an act of choosing or choice between two or more courses of conduct, or between action and inaction, it is evident that by far the greater portion of our acts occur without conscious exercise of this faculty. Walking along a muddy street, engaged in deep thought or earnest conversation with a friend, one picks his way, but consciously does not determine where at each step his foot is to be placed. We laugh when amused; weep from sympathy or grief; cry from pain; become agitated, irritable, excited, or angry, if sufficiently vexed, without previous choice whether or not we shall yield to these emotions. We speak of ourselves as acting "from the impulse of the moment," from habit, or "as we always do under such

circumstances." Let any one, for instance, review in his mind the events of yesterday, from the first moment of awakened consciousness until he sank into slumber at night, and remember, if he can, before how many of the ten thousand actions which constituted his daily life he paused to choose. Awakened in the morning, he arose, doubtless, at his usual hour—performed ablution, assumed his garments, one by one, in a certain methodical order, and descended to breakfast. He read portions of his newspaper; commented on events or politics; the coffee was burned and the steak tough, and he was irritable and morose; or both were excellent, and he was amiable and talkative. He walked to his place of business by the route he always takes; crossing the streets where he had crossed a thousand times previously; arriving at the usual hour, notwithstanding he might have made—had the motives existed—innumerable variations from his regular course in each of these proceedings. Now, up to this point, he has probably performed several thousand distinct muscular efforts, each under the control of his will—from the glance of an eye to the propulsion of his body along the street. How many of them can he remember, or does he suppose to have resulted from conscious choice between action as performed and another imaginable possible alternative? Probably he could count on his fingers all the acts of conscious choice performed during the entire day. The rest have been as instinctive and impulsive, as unconsciously determined by circumstances, as the operations of ordinary animal existence.

Turning now to the consideration of those acts which are preceded by that conscious weighing of motives which constitutes true volition, we shall find these no less determined by law. Appealing confidently to the consciousness of every reader, I submit that *we not only invariably choose, but we* CAN ONLY CHOOSE, *that object or course of action which at the instant, the will is exercised to choose, appears to us, all things considered, the most desirable.*

This can hardly be doubted. For the very act of conscious choice implies of necessity (except in those imaginary cases of absolute indifference wherein morality can not be concerned) *a preference*, even if it be only momentary. Mind, I do not say the thing chosen is really desirable; perhaps the only courses open are all very undesirable, terrible, full of painful consequences, and the confused mind may pass from one to another with a hesitating tremulousness of indecision—obliged, however, ultimately to make a choice. Put yourself to any fair test, and see if you can possibly choose that which you prefer least to choose. Pain is exceedingly undesirable, is it not? Take a needle and place the point against your bared arm; now choose whether or not you shall force it to enter your flesh. "But it will hurt me," you say, and you throw down the needle, proceeding no further. Do you so decide *without cause?* Or perhaps you push the point beneath the skin, and inflict upon yourself pain, without apparent adequate motive.

Yet is it not evident that the mere desire to make the experiment made even the pain momentarily desirable? But, omitting the petty experiences of our every-day life, let us test the proposition by reference to the highest occasions of choice possible to man. Life is sweet, and yet how poor would be the records of heroism did they not tell us of men who, for the sake of great and noble ends, preferred death! You can not imagine them as choosing it if they did not regard it as the more desirable. We have all seen the picture of the Huguenot lovers, on the eve of St. Bartholomew, and the choice of death which one made even in the arms of her he loved. How many martyrs in silent dungeons have been offered life, liberty, home, and the loving companionship of wife and children, the possibility of long years of happiness and usefulness, at the price of apostasy to their convictions; who chose rather an ignominious death at the stake, prolonged tortures, confiscation of property, beggary of children, execration of friends, a dishonored and forgotten name—and whose faces shone with happiness as the flames kindled around them! But men have chosen more than this—not only to die, but to live a life of torture first. History does not record for us instances of greater self-abnegation, of more intense eagerness to suffer and to die for others, than those of the Jesuit missionaries who labored among the Indians of this country two centuries ago. One of them, writing from the Iroquois country in 1644, said: "This letter is soiled and ill-written, because the writer has only one finger of his right hand left entire, and can not prevent the blood oozing from his wounds, still open, from staining the paper." He had suffered protracted tortures in every form consistent with the preservation of life: given to children to torment; burned with live coals, forced to walk on hot cinders, hung by the feet, lacerated by savage dogs; a finger-nail burned off one day, and the joint burned off the next—a fiendish economy of torture—and finally ransomed by the Dutch, only to save him from the stake; yet, as soon as his health was partially restored, he chose to embark again for the wilderness and its awful possibilities. Turn the yellow pages of the missionary "Relations" and you come upon sentiments like these, expressed in the antiquated orthography of the time: "Nous mourrons, nous serons pris, nous serons bruslez, nous serons massacrez—passe. Je ne voy icy personne baisser la tête; au contraire—on demande de monter aux Hurons; et quelques uns protestent *que les feux des Hiroquois sont l'un de leur motifs pour entreprendre un voyage si dangereux!*" Of others, their biographer says: "They had borne all that the human frame seems capable of bearing. They had escaped as by miracle from torture and death. Did their zeal flag or their courage fail? A fervor, intense and unquenchable, urged them on to more distant and more deadly ventures. They burned to do, to suffer, to die; and now from out a living martyrdom they turned their heroic gaze toward a horizon dark with perils yet more appalling, and saw in hope the day

when they might bear the cross into the blood-stained dens of the Iroquois." In the tortured captives they had baptized even amid the flames, they saw their own fate, but it caused not a moment's hesitation. These all chose *what to them semed most desirable;* for, beyond torture and death, they seemed to see the martyr's crown, the eternal reward. Not less on these supreme occasions than in the most ordinary affairs of daily life, *choice is determined by the apparent desirableness of things.*

But, if this be granted, it immediately becomes evident that one's views of what is desirable arise from an infinite variety of coincident circumstances with which the individual concerned had no more to do than with the shape of his skull or the color of his skin. That no two persons have exactly the same preferences or tastes, or would choose alike on every occasion, is a truism. Their ideas of what is desirable may have resulted from congenital or inherited constitutional tendencies. A drunkard's children are often endowed with a craving for stimulants, that sooner or later brings them to drunkards' graves. One man possesses fierce and strong animal propensities; another is never tempted by vicious allurements. The social condition of men has a great influence in this respect. I do not suppose the Prince of Wales ever perceived the desirableness of snatching a loaf from a baker's cart; but many a starving London tramp has felt it. Hunger and poverty meet a thousand temptations that never assail full stomachs and well-clothed bodies. Victor Hugo says that English statistics prove four robberies out of five to have hunger for their immediate cause. Or the state of the health may influence men's views of the desirableness of things. Of the effect of impaired vitality in vitiating desires, every physician is aware. Many of us, offered a glass of wine, could accept it without the remotest danger of thereby becoming drunkards; but others, men like Mr. Gough, tell us that for them such indulgence would be the first step to a long debauch. How powerful is the influence of habit in this respect! I enter a tobacconist's with no other desire apparent to myself than to do my errand and escape as soon as possible; but a venerable gentleman told me the other day that, after breaking off the use of tobacco for thirteen years, the chance inspection of some fresh samples renewed with overwhelming force the old appetite and refixed the old habit. Or the decision may be due to occasion and other surrounding circumstances attending the moment of choice. There is a profound significance in the petition, "Lead us not into temptation." Many a woman walks our streets wrecked, from the fortuitous conjunction of opportunity, temptation, and desire, whose virtue would never have yielded to either alone. What an immense influence is exerted upon men's desires by their religious belief! The Jesuit among the Hurons could choose a daily martyrdom that, now and then, he might touch a dying papoose with holy water and snatch its little soul from eternal fires;

can we imagine a Universalist clergyman so suffering for such results? How largely also are our notions of right and wrong determined for us by early parental training! A landlady of mine, in Leipsic, a pastor's daughter, of the most rigid type of Protestant orthodoxy, attended church one Sunday morning, and a representation of "Faust" at the theatre the same evening; and saw no incongruity in a course which, by a majority of people in this country, would be regarded as a fearful sin. Both views of Sunday are merely results of religious education at a period when the mind is peculiarly receptive, and when no one claims that a child should decide as to the correctness of the opinions taught. These are only a few out of the infinite number of circumstances, beyond individual control, which decide what shall be the views we take of the qualities of things and the desirableness of action. They mold character; they shape opinions; they make the man what he is. Since by these facts of organization, education, religious training, social position, etc., independent of our wish or will, are determined for us the views we invariably take of the apparent desirableness of all objects or actions—since upon this apparent desirableness the choice of conduct of mankind invariably depends—it follows that the human will is as subject to the law of causation as the movements of the planets or the flight of an insect in the air.

It is asserted, however, by the advocates of the popular doctrine, that the scientific negation of free-will obliterates what is called "moral responsibility," and places man, as respects his actions, on the plane of other animals. A full consideration of this point would lead us too far aside from our subject; yet, were all imagined consequences sure to arise from general disbelief in accountability for action, I fail to see how this proves the truth of the doctrine of free-will. It can never be too often repeated that, regarding each and every theory, dogma, or proposition, Science can ask but one question, *Is it true?* The answer must come from other sources than the imagined sequence of its acceptance or rejection. But let us suppose that mankind should some day admit the proposition that moral responsibility, in the theological sense, does not exist; that the will is determined by the strongest motive: what fearful results would ensue! Would punishment cease to follow crime? On the contrary, its use would never be more logical. If the stronger motive has led an individual to transgress the rights of society, then society must punish for three reasons: 1. That the memory of the punishment may act as a strong motive in deterring from future repetition of the offense; 2. That the example may deter others; and, 3. That society may be protected from a dangerous man. These reasons are all consistent with the doctrine of necessity; what others would the advocates of uncaused volition add? To assert that punishment should only be inflicted where "moral responsibility" exists, is either to confer it upon our domestic animals, or else to deny the justice of our every-day action regarding them. A child throws

stones at strangers passing by; a dog barks at their heels; both are soundly whipped at each offense, and sooner or later both cease its repetition. In both instances punishment was given from the same standpoint; its action on child and dog was alike—equally effectual, and I see no reason for the interposition of moral responsibility in the one case, if denied in the other.

I do not believe that the doctrine of necessity, if generally held, would lessen in any way our abhorrence of evil, or our approval of the good. To assert, as Professor Bascom does in his recent work on "Ethics," as a proof of free-will, that the doctrine of necessity "does not merely strangle virtue—it leaves every thought and action as true and as just, one as another," and that "all our moral action loses its character without liberty," seems to me to make statements unsupported by any evidence whatever. Would Professor Bascom allow that Deity is free to become a fiend? And if not—if to be God he must *of necessity* be good—does he conceive that divine action "loses its character without liberty"? Or can he explain why conduct should be deprived of the distinctions of good and evil because conditioned, any more than physical qualities admitted to be determined independently of the individual's will? If beauty in the human form is better than ugliness, health than disease, symmetry than distortion, intelligence than idiocy, why should not modesty, humanity, justice, and truth, not only seem, but *be* better than profligacy, cruelty, iniquity, and falsehood? The fact is, goodness is essentially beautiful, and in the slow progress of mankind upward, from savagery to the ultimate civilization yet to be, can not fail to command admiration. Evil is hateful, independently of its relations to ethics, and its awful realm extends far beyond the area of human action. In the spider springing upon the entangled fly, the cat playing with its victim before tearing it to pieces, in the teeth of the shark, the fangs of the rattlesnake, the poisonous slaver of the rabid dog; in the deposition of tubercle, the slow growth of cancer, the ravages of syphilis upon innocent childhood, we get glimpses of the great mystery of Evil, separate from human will, where we pity but never condemn. And if, perchance, some day the world should learn to discriminate in the sphere of human action between the deed and doer; if, acknowledging necessity, it should come to have a larger and more comprehensive charity for all mankind, will it have strayed very far from the example and precepts of the world's great Teacher? Was there not one who, hating leprosy, loved the leper?—about whom Pharisees murmured because he sat at meat with sinners?—who condemned not her whom the law would have stoned?—who taught that "it must needs be that offenses come," and whose last prayer asked forgiveness for his enemies, "for they know not what they do"? I do not believe these dying words were without meaning; they were the expression of a scientific truth.

Nor, finally, will belief in the conformity of will to law hinder our

approval and admiration of great and good deeds. The highest and noblest action results never from conscious choice, but springs unconsciously from the force of noble character—"instinctively," as we sometimes say. Of Cato, it was said that he was good because he could not be otherwise. So far from lessening the excellence of conduct that noble motives act always with irresistible force upon great men, that is the chief reason for honoring them, because they at least could not act ignobly. "Here I stand," said Luther, at Worms, "God help me, ICH KANN NICHT ANDERS!" This is the key-note of noble action everywhere, "I can not otherwise!" The engineer, at New Hamburgh, hesitating not a moment when duty called him to a horrible death; the captain of the sinking steamer who will not leave the ship until every passenger is safe, and so goes down with her; Arnold Winkelried crying, "Make way for liberty!" and rushing upon the Austrian spears; Sir Philip Sidney, mortally wounded, taking from his parched lips the water brought him, that a poor soldier, who looked longingly with dying eyes at the cup, might first drink; the martyrs who have chosen to suffer ignominy and death that we might have freedom of thought and speech—these are types of men humanity will ever honor; their example and memory we shall reverence even though we know—rather *because* we know—that the needle points not more surely to the pole than that for them, there and then, meanness was impossible—that their great souls were only capable of noble deeds.

EXPERIMENTAL LEGISLATION.

By Professor W. STANLEY JEVONS.

"A FOOL, Mr. Edgeworth, is one who has never made an experiment." Such are, I believe, the exact words of the remark which Erasmus Darwin addressed to Richard Lovell Edgeworth. They deserve to become proverbial. They have the broad foundation of truth and the trenchant disregard of accuracy in detail which mark an adage. Of course, the saying at once suggests the question, What is an experiment? In a certain way, all people, whether fools or wise men, are constantly making experiments. The education of the infant is thoroughly experimental from the very first, only in a hap-hazard and unconscious way. The child which overbalances itself in learning to walk is experimenting on the law of gravity. All successful action is successful experiment, in the broadest sense of the term, and every mistake or failure is a negative experiment, which deters us from repetition. Our mental framework, too, is marvelously contrived, so as to go on ceaselessly registering on the tablets of the memory the favorable or unfavorable results of every kind of action. Charles Babbage

proposed to make an automaton chess-player which should register mechanically the number of games lost and gained in consequence of every sort of move. Thus, the longer the automaton went on playing games, the more experienced it would become by the accumulation of experimental results. Such a machine precisely represents the acquirement of experience by our nervous organization.

But Erasmus Darwin doubtless meant by experiment something more than this unintentional heaping-up of experience. The part of wisdom is to learn to foresee the results of our actions, by making slight and harmless trials before we commit ourselves to an irrevocable line of conduct. We ought to feel our way, and try the ice before we venture on it to a dangerous extent. To make an experiment, in this more proper sense, is to arrange certain known conditions, or, in other words, to put together certain causal agents, in order to ascertain their aggregate outcome or effect. The experiment has knowledge alone for its immediate purpose. But he is truly happy, as the Latin poet said, who can discern the causes of things, for, these being known, we can proceed at once to safe and profitable applications.

It need hardly be said that it is to frequent and carefully planned appeals to experiment in the physical sciences that we owe almost all the progress of the human race in the last three centuries. Even moral and intellectual triumphs might often be traced back to dependence on physical inventions, and to the incentive which they give to general activity. Certainly, political and military success is almost entirely dependent on the experimental sciences. It is difficult to discover that, as regards courage, our soldiers in Afghanistan and Zoolooland are any better than the men whose countries they invade. But it is the science of the rifle, the shell, and the mountain-gun—science perfected by constant experimentation—which gives the poor savage no chance of successful resistance. To whom do we owe all this in its first beginning, but to the great experimentalist, the friar, Roger Bacon, of Oxford, our truest and greatest national glory, the smallest of whose merits is that he first mentions gunpowder; yet so little does this nation yet appreciate the sources of its power and greatness that the writings of Roger Bacon lie, to a great extent, unprinted and unexplored. It is only among Continental scholars that Roger Bacon is regarded as the miracle of his age and country.

No doubt it is to Francis Bacon, the Lord High Chancellor of England, that the world generally attributes the inauguration of the new inductive era of science. This is hardly the place to endeavor to decide whether the world has not made a great mistake. Professor Fowler, in his admirable critical edition of the "Novum Organum," has said about all that can be said in favor of Lord Bacon's scientific claims; yet I hold to the opinion, long since stoutly maintained by the late Professor De Morgan, not to speak of Baron Liebig and others,

that Lord Bacon, though a truly clever man, was a mere dabbler in inductive science, the true methods of which he quite misapprehended. At best, he put into elegant and striking language an estimate of the tendency of science toward experimentalism, and a forecast of the results to be obtained. The regeneration of these last centuries is due to a long series of philosophers, from Copernicus, Galileo, Descartes, Newton, Leibnitz, down to Watt, Faraday, and Joule. Such men followed a procedure very different from that of Francis Bacon.

Now we come to the point of our inquiry. Is the experimental method necessarily restricted to the world of physical science? Do we sufficiently apply to moral, social, and political matters those methods which have been proved so invaluable in the hands of physical philosophers? Do our legislators, in short, appeal to experiment in a way which excepts them from the definition of Erasmus Darwin? English legislation, no doubt, is usually preceded by a great amount of public discussion and Parliamentary wrangling. Sometimes there is plenty of statistical inquiry—plenty, that is, if it were of the right sort and conducted according to true scientific method. Nevertheless, I venture to maintain that as a general rule Parliament ignores the one true way of appealing directly to experience. Our Parliamentary Committees and Royal Commissions of Inquiry pile up Blue-books full of information which is generally not to the point. The one bit of information, the actual trial of a new measure on a small scale, is not forthcoming, because Parliament, if it enacts a law at all, enacts it for the whole kingdom. It habitually makes a leap in the dark, because I suppose it is not consistent with the wisdom and dignity of Parliament to grope its way, and feel for a safe footing. Now, I maintain that, in large classes of legislative affairs, there is really nothing to prevent our making direct experiments upon the living social organism. Not only is social experimentation a possible thing, but it is in every part of the kingdom, excepting the palace of St. Stephen's, the commonest thing possible, the universal mode of social progress. It would hardly be too much to say that social progress is social experimentation, and social experimentation is social progress. Changes effected by any important act of Parliament are like storms, earthquakes, and cataclysms, which disturb the continuous course of social growth. Sometimes they do much good; sometimes much harm; but in any case it is hardly possible to forecast the result of a considerable catastrophic change in the social organism. Therefore I hold unhesitatingly that, whenever it is possible, legislation should observe the order of nature and proceed tentatively.

Social progress, I have said, is social experimentation. Every new heading that is inserted in the London Trades' Directory is claimed by those private individuals who have tried a new trade and found it to answer. The struggle for existence makes us all look out for chances of profit. We are all perhaps in some degree inventors, but

some are more bold and successful. Now, every man who establishes a shop or factory or social institution of a novel kind is trying an experiment. If he hits an unsupplied need of his fellow men, the experiment *succeeds;* that is, it has something succeeding or following it, namely, repetition by himself and others. The word "success" is a most happy one etymologically. To have success is to have a future —a future of imitators.

It is quite apparent that all the great novelties of recent times have been worked out in this tentative way. How, for instance, has our vast and marvelous railway system been developed? Did it spring forth perfect from the wise forethought of Parliament, as Minerva, fully armed and equipped, leaped from the head of Jupiter? On the contrary, did not our wise land-owners and practical men oppose railways to the very utmost—until they discovered what a mistake they were making? There is no great blame to them. Who, indeed, could see in the rude tram-line of Benjamin Outram the germ which was to grow into the maze of lines, and points, and signals which we now pass through without surprise at Clapham Junction or at London Bridge? That most complex organization, a great railway station, is entirely a product of frequent experiment. *Gradatim*—step by step —would be no unapt motto for any great industrial successes. In such matters experiments are both intentional and unintentional. Of the former the public hears little, except when they result in some profitable patent. The preliminary trials are usually performed in secret, for obvious reasons, and the unsuccessful ones are left undescribed and are quickly forgotten. As to unintentional experiments, they are too numerous. Every railway accident which happens is an experiment revealing some fault of design, some insufficiency in the materials, some contingency unprovided for. The accident is inquired into, and then the engineers set to work to plan improvements which shall prevent the like accident from happening in the future. If we had time to trace the history of the steam-engine, of gas-lighting, of electric telegraphs, of submarine cables, of electric lighting, or of any other great improvement, we should see, in like manner, that the wisdom of Parliament has had nothing to do with planning it. From the first to the last the rule of progress has been that of the ancient nursery rhyme—"Try, try, try: And if at first you don't succeed, Try, try, again."

To put the matter in the strongest light, let the reader consider what he would say about a proposal that Parliament should decide arbitrarily, by its own wisdom, concerning any great impending improvement; take, for instance, that of tramways and steam tram-cars. It is quite conceivable that steam tram-cars will eventually succeed so well as to replace horse conveyance to a great extent. All main highways will then, of course, be laid with tram-rails. But what should we think of the wisdom of Parliament if it undertook to settle the

question once for all, and, after taking a score of Blue-books full of evidence, to decide either that there should be no steam tram-cars, or that steam tramways should be immediately laid down between all the villages in the kingdom? The House of Lords did take the former course two sessions ago, and prohibited the use of steam on tramways, because it might frighten horses. In the next session they felt the folly of opposing the irresistible, and expressly allowed the *experimental use* of steam on tramways.

It may, perhaps, be objected that these are matters of physical science and practical engineering, in which the supremacy of experiment has long been recognized. That is not wholly so; for the success of a system, like that of the railways or tramways, depends much upon social considerations. However that may be, there is no difficulty in showing that the same principles apply to the most purely social institutions. If anything, it is the social side of an enterprise which is usually most doubtful, and most in need of experiment when it can be applied. To construct the Thames Tunnel was a novel and difficult work at the time, but not so difficult as to get the populace to use it. The Great Eastern steamship was another instance of a great mechanical success, which was a social and economical failure. Many like cases might be mentioned, such as the real-ice rinks lately invented.

How is it that any kind of purely social institution is usually established? Take the case of the Volunteer Force. This was commenced, not to speak of earlier movements, or the ancient Honorable Artillery Company, by a few isolated experiments, such as that of the Exeter Rifle Corps in 1852, and the Victoria Rifle Corps in 1853. These succeeded so well that, when in 1859 fears of invasion were afloat, the imitative process set in rapidly. Of course wise, practical people laughed at the mania for playing at soldiers, and most people clearly foresaw that, when once the volunteers had got tired of their new uniforms, the whole thing would collapse. But experience has decided very differently. The force, instead of declining, has gone on steadily growing and substantially improving, until a good authority lately spoke of it as the only sound part of our military system. How much has the wisdom of Parliament had to do with the creation of this force? I believe that even now the Government and the military classes do not appreciate what the volunteer force has done for us by removing all fear of safety at home and enabling the standing army to be freely sent abroad.

Take, again, the case of popular amusements. Would Parliament ever think of defining by act of Parliament when and how people shall meet to amuse themselves, and what they shall do, and when they shall have had enough of it? Must not people find out by trial what pleases and what does not? The late Mr. Sergeant Cox is said to have invented penny readings for the people, and they answered so

well under his management that they were imitated in all parts of the kingdom, and eventually in many other parts of the world. Spelling-bees were, I believe, an American invention, and had a very lively but brief career. The recent courses of popular scientific lectures arose out of the very successful experiment instituted by Professor Roscoe at Manchester. Many attempts are just now being made to provide attractive and harmless amusements for the people, and this must, of course, be done in a tentative manner.

It is curious, indeed, to observe how evanescent many social inventions prove themselves to be; growth and change have been so rapid of late that there is constant need of new inventions. The Royal Institution in Albemarle Street was a notable invention of its time, chiefly due to Count Rumford, and its brilliant success led to early imitation in Liverpool, Manchester, Edinburgh, and perhaps elsewhere. But the provincial institutions have with difficulty maintained their *raison d'être*. After the Royal Institutions came a series of Mechanics' Institutions, which, as regards the mechanics element, were thoroughly unsuccessful, but proved themselves useful in the form of popular colleges or middle-class schools. Now, the great and genuine success of Owens College, as a teaching body, is leading to the creation of numerous local colleges of similar type. This is the age, again, of free public libraries, the practicability and extreme usefulness of which were first established in Manchester. When once possessed of local habitations, such institutions will, it may be hoped, have long careers; but bricks and mortar are usually requisite to give perpetuity to a social experiment. When thus perpetuated, each kind of institution marks its own age with almost geologic certainty. From the times of the Saxons and the Normans we can trace a series of strata of institutions superposed in order of time—the ancient Colleges of Oxford and Cambridge, the mediæval guilds surviving in the city companies, the grammar-schools of the Elizabethan age, the almshouses of the Stuart period, the commercial institutions of Queen Anne's reign, and so on down to the free libraries and recreation palaces of the present day. Even styles of architecture are evolved by successful innovation, that is, experiment followed by imitation, and this was never more apparent than in the imitation which has followed upon Sir Joseph Paxton's grand experiment at the Exhibition of 1851.*

Now, my contention is that legislators ought, in many branches of legislation, to adopt confessedly this tentative procedure, which is the very method of social growth. Parliament must give up the pretension that it can enact the creation of certain social institutions to be carried on as specified in the "hereinafter contained" clauses. No

* I do not remember to have seen the importance of this imitative tendency in social affairs described by any writer, except the French engineer and economist Dupuit, who fully describes it in one of his remarkable memoirs, printed in the "Annales des Ponts et Chaussées."

doubt, by aid of an elaborate machinery of administration and a powerful body of police, Government can, to a certain extent, guide, or at any rate restrain, the conduct of its subjects. Even in this respect its powers are very limited, and a law which does not command the consent of the body of the people must soon be repealed or become inoperative. But, as regards the creation of institutions, Parliament is almost powerless, except by consulting the needs of the time, and offering facilities for such institutions to grow up as experience shows to be successful. But an unfortunate confusion of ideas exists, and it seems to be supposed that, because for reasons of obvious convenience the civil and criminal laws are as a general rule made uniform for the whole kingdom, therefore the legislative action of Parliament must always be uniform and definitive. When an important change is advocated, for instance, in the licensing laws, Parliament collects abundant information, which is usually inconclusive, and then proceeds to effect all over the kingdom some very costly and irrevocable change—a change which generally disappoints its own advocates. Take the case of the Sale of Beer Act of 1830, generally known as the Beershop Act. This is a salient example of bad legislation. Yet it was passed by the almost unanimous wisdom of Parliament, the division in the House of Commons on the second reading showing two hundred and forty-five ayes and only twenty-nine noes. The act originated with Brougham, in the sense that he had in 1822 and 1823 brought in somewhat similar bills, which were partially adopted by the Government of 1830. The idea of the act was to break down the monopoly of the brewers and publicans; to throw open the trade in beer on free-trade principles; and, by offering abundance of wholesome, pure, weak beer, to draw away the working classes from the gin-shops. All seemed as plausible as it was undoubtedly well intended. Objections were of course made to the bill, and many people predicted evil consequences; but all such sinister predictions were supposed to be spread about by the interested publicans and brewers. Nevertheless, the new act was soon believed to be a mistake. Sydney Smith, though he had not many years before pleaded for liberty for the people to drink rum-and-water, or whatever else they liked ("Edinburgh Review," 1819), quickly veered round, and gave a graphic account of the beastly state of drunkenness of the sovereign people.

It may be safely said that the Beershop Act realized all the evils expected from it, and few or none of the advantages. It is difficult to say anything in favor of the bar at the corner public-house, except that it is better than the dirty low little beershop, hiding itself away in some obscure recess of the streets. The first is at any rate under the gaze of the public and the control of the magistrates; the beershop, until within the last few years, was too likely to become the uncontrolled resort of the worst classes. Even now that the beershops are brought under the Licensing Magistrates, many years must elapse

before the evil wrought by the act of 1830 can be thoroughly removed. This, then, is a striking instance of a leap in the dark, which ought never to have been committed by a prudent Legislature. When the Sale of Beer Bill was under discussion, the Chancellor of the Exchequer seemed to feel that it was a bill which needed experimental trial; for, when objection was made that the act would not extend to Scotland, he urged that it might be better to try the act in one part of the kingdom in the first instance, and then, if it were found to be beneficial, and to answer its intended objects, it might be extended to other parts.*

In more recent years the granting of grocers' licenses for the free sale of all kinds of spirituous liquors is likely to prove itself to be an equally disastrous leap in the dark. With the very best intentions, and on the most plausible theoretical grounds, Mr. Gladstone's Government greatly extended the free sale of wine and beer, so that now, in some popular watering-places, I have noticed that almost every third shop-window is ornamented with a pyramid of beer-bottles. Yet the late Government have only succeeded in making the grocers' shop the avenue to the publican's bar. No one can for a moment believe that the free sale of liquors for home use has in the least degree weakened the publican's hold on his customers. If I had on *a priori* grounds to plan out a scheme of liquor-traffic, I should just reverse the existing law relating to beershops and grocers' licenses. I would prohibit the "off" sale of liquor on any premises where other articles were sold; the purchaser desiring to buy wine, beer, or spirits for home use should be obliged to go to some one of a comparatively few well-marked shops dealing in those things alone. On the other hand, where liquor is sold for consumption on the premises, I should oblige the seller to furnish food and reasonable sitting accommodation. This would be nothing more than a return to the old law about licensed victualers, which yet exists in the letter, though it has been allowed to fall into practical abeyance. The very reasonable law obliging publicans to afford general entertainment was sadly broken down by the Beershops Act, which provided unlimited means for the drinking of beer, pure and simple, without food of any kind. But my contention is, that we must not proceed in such matters on *a priori* grounds at all. We must try.

Perhaps it may be said that every new law is necessarily an experiment, and affords experience for its own improvement, and, if necessary, its abrogation. But there are two strong reasons why an act which has been made general, and has come into general operation, can seldom serve as an experiment. Of course, a great many acts of Parliament are experimentally found to be mistaken, for they never come into considerable operation at all, like the acts to promote registration of titles, not to mention the Agricultural Holdings Act. Such

* "Hansard's Debates," April 8, 1830, New Series, vol. xxiv., p. 26.

cases prove little or nothing, except the weakness, and possibly the insincerity, of the Legislature. But if an act comes largely into operation it is practically irrevocable. Parliament can not say simply "as you were," and proceed to a new and more hopeful experiment. A social humpty-dumpty can not be set up again just as it was before even by the Queen's men. The vested interests created are usually too formidable to be put aside, and too expensive to be bought up. A good many years, say seven, or ten at the least, are needed to develop properly any important legislative experiment, so that the same generation of statesmen would not have more than three or four opportunities of experiment in the same subject during the longest political career. If we divide up the country, and try one experiment on one town or county, and another on another, there is a possibility of making an almost unlimited number of valid trials within ten or twenty years. But, apart from this consideration, a general legislative change is not a true experiment at all, because it affords no clear means of distinguishing its effects from the general resultant of social and industrial progress. Statistical facts are usually numerical or quantitative in character, so that, if many causal agencies are in operation at the same time, their effects are simply added together algebraically, and are inextricably merged into a general total. Thus, the total numbers receiving poor-law relief, or the numbers apprehended in the kingdom for drunkenness, are numerical results affected by the oscillations of trade, by the character of the seasons, the value of gold, etc., etc., as well as by the acts of the Legislature. To make a valid experiment we must have a certain thing subject to certain constant conditions, and we must introduce a single definite change of condition, which will then be probably the cause of whatever phenomenon follows. It is possible, indeed, to experiment upon an object of varying conditions, provided we can find two objects which vary similarly; we then operate upon the one, and observe how it subsequently differs from the other. We need, in fact, what the chemists call a "blind experiment." Suppose, for instance, that an agricultural chemist or a scientific farmer wished to ascertain the effect of a new kind of manure; would it be rational for him to spread the manure over all his available land? Would it not then be doubtful whether the increase or decrease of yield were due to the manure or to the character of the seasons? In this case his neighbors' crops might, to some extent, furnish the blind experiment, showing what had been the ordinary yield. But, of course, the obvious mode of procedure is to spread the new manure over a part only of each experimental field, so that the difference of the crops on the different patches brings out, in the most unquestionable way, the effect of the manure. Not only is the smaller experiment, in a logical point of view, far better than the larger one, but it is possible to try many concurrent small experiments upon a farm of moderate extent.

I maintain that, if our legislators are to act rationally, they will as far as possible imitate the agricultural chemist. The idea, for instance, of obliging, or even allowing, all the boroughs in the kingdom simultaneously to adopt the Gothenburg plan, would be ridiculous and irrational. The cost and confusion which would arise from a sudden general trial must be very great; many years would elapse before the result was apparent. And that result would not be so clear as if the trial were restricted to some half a dozen towns. In the mean time it would be far better that other boroughs should be trying other experiments, giving us many strings to our bow, while some towns would actually do best for the country by going on as nearly as possible in their present course. Specific and differentiated experience is what we need, before making any further important change in the drink-trade.

Not only is this the rational method of procedure, but it is practically the method to which we owe all the more successful legislative and administrative reforms of later years. Consider the Poor Law question. During the eighteenth century, Parliament made two or three leaps in the dark, by enacting laws such as Gilbert's Act, and very nearly ruined the kingdom by them. The great Poor Law Commission commenced its operations in the soundest way by collecting all available information about the treatment of the poor, whether at home or abroad. But, what is more to the point, since the new Poor Law was passed in 1834, the partially free action of Boards of Guardians, under the supervision of the Poor Law Commission and the Poor Law Board, has afforded a long series of experimental results. The reports of Mr. Edwin Chadwick and the late Sir George Shaw Lefevre are probably the best models of the true process of administrative reform to be anywhere found. In more recent years several very important experiments have been tried by different Boards of Guardians, such as the boarding out of pauper children, the suppression of vagrancy by the provision of separate vagrant cells and the hard-labor test, and the cutting down of outdoor relief. If the total abolition of outdoor relief is ever to be tried, it must be tried on the small scale first; it would be a far too severe and dangerous measure to force upon the whole country at a single blow. Much attention has lately been drawn to the so-called "Poor-Law Experiment at Elberfeld," which was carefully described by the Rev. W. Walter Edwards, in an article in the "Contemporary Review" for July, 1878, bearing that precise title.

Even when an act of Parliament is passed in general terms applying to the whole kingdom at once, it by no means follows that it will be equally put into operation everywhere. The discretion necessarily allowed to magistrates and other authorities often gives ample scope for instructive experiments. Some years since the Howard Association called attention to what they expressly called "The Luton Experiment," consisting in the extraordinary success with which the magis-

trates of Luton in Bedfordshire enforced the provisions of the "Prevention of Crime Act." The number of committals to jail from Luton and its vicinity was reduced from two hundred and fifty-seven in 1869 to sixty-six in 1874. The only fault of the experiment consists in the possibility that the thieves and roughs migrated, but this difficulty would be less serious had the experiment been tried in larger towns.

What little insight we can gain into the operation of the licensing laws is mainly due to the considerable differences with which they have been administered in different places. Such is the latitude of discretion given by the law that magistrates can often make very distinct experiments. A short time ago the magistrates of Glasgow intentionally and avowedly made the experiment of locking up in jail all the drunkards brought before them. When I last heard about this experiment it was on the point of failing, because the jails of Glasgow were all quite full, and still the drunkards were coming to the bar. In 1863 the Licensing Magistrates of Liverpool commenced a most interesting experiment, by declaring their intention to adopt "free licensing," that is, to grant licenses to any suitable persons who applied for them. The publicans' licenses were increased from sixteen hundred and seventy-four in 1862 to nineteen hundred and forty in 1866. The system was abandoned in this last year, owing to a change in the constitution of the Bench. None of the magistrates who advocated the change, we are told, ever recanted, but some who supported the change to a restrictive policy have been disappointed with the results. The teaching of this real experiment has been carefully discussed by Mr. S. G. Rathbone in a very able letter, published in the "Times" of the 12th of February, 1877, as also in his evidence before the Lords' Committee of Inquiry on Intemperance (questions 259–384, etc.). But, apart from his objections to the interpretation put upon the facts, the experiment was not continued sufficiently long, and the town in which it was tried is so unique in the annals of intemperance as to be ill-fitted for the purpose.

Much attention has been drawn recently to the merits of the so-called Gothenburg scheme, the adoption of which has been so ably advocated by Mr. J. Chamberlain, M. P. Now, what is this advocacy but argument from a successful experiment? The municipal authorities of Gothenburg allowed a certain method of conducting the sale of liquor to be tried there, and the success was apparently so great that other Swedish towns are rapidly adopting the same plan. This is just the right procedure of trial and imitation. But, if Mr. Chamberlain means that, because the plan succeeds in Gothenburg, therefore the municipal authorities of English towns ought at once to be obliged to purchase and administer the public-houses, he goes much too far. All we ought to do is to try the system in a limited number of towns. Any one acquainted with the bright little Swedish seaport, and the orderly, polished lower-class population of Sweden, will be in no hurry

to draw analogies between their condition and that of our great, busy, turbulent Anglo-Irish towns. At any rate it is obvious that experiments ought to be made upon the most closely proximate cases which can be found, and, if three or four such towns as Birmingham, Bristol, Bolton, and Newcastle-upon-Tyne could be induced to try the Gothenburg scheme, it would be an ample first experiment. Even between English towns the differences of magnitude, race, occupation, and local government are often so great that it is by no means certain that the same scheme will succeed equally in all. The differences in the intemperance rates in the several boroughs of England, to which I shall perhaps draw attention on a future occasion, are so extraordinary and profound that the Committee of the House of Lords were thoroughly bewildered on the subject. Under such circumstances it should not be assumed that uniform legislation must be the ultimate object of our efforts.

It is a most important question how far the proposals of the United Kingdom Alliance for the Suppression of the Liquor Traffic can be approved from the point of view here taken up. I venture to maintain that those proposals, so far as embodied in the Permissive Prohibitory Bill, now dropped, had all the possible evils of a great legislative leap in the dark, with few of the corresponding possible advantages. Four years ago, in a paper read to the Manchester Statistical Society, I gave reasons for believing that the long-continued and costly proceedings of the Alliance were simply thrown away, except so far as they might be a warning against similar unwise attempts at legislation. I showed that the Alliance were striving against triple improbabilities: firstly, the improbability (as manifested by the decreasing ratio of the ayes to the noes in the House of Commons' divisions) that Parliament would ever pass the bill; secondly, the improbability that, if passed, the Permissive Act would be largely adopted by local authorities; thirdly, the improbability that, if adopted, it would succeed in lessening intemperance. According to the mathematical principle of the composition of probabilities by multiplication, the probability that any good would ever result from an agitation costing more than a quarter of a million pounds, and extending already beyond a quarter of a century in duration, was practically *nil*. The only effective answers given to my arguments were those of the Rev. Mr. Steinthal and one or two others, who held that the probabilities in question are not altogether independent, because Parliament could hardly be forced to pass the bill unless there were extensive localities wishing to adopt it. There is a certain amount of truth in this objection, but it does not to any great degree strengthen the position of the Alliance. Their proposals in their original form seem to me to have the character of a vast experiment—so vast that it was intended to involve the extinction of the trade of publicans and liquor-dealers generally in all parts of the country. Now, that is an experiment, be-

cause it is exceedingly doubtful whether the population would tolerate such an interference with their habits, when the meaning of the act came home to them. The information which we can draw from Maine, or other places where prohibition of the traffic has existed, is most conflicting in itself, and remote in analogy. Accordingly, I should much like to see the prohibition of the public sale of liquor tried in several large English boroughs and districts, provided that the necessary act for the purpose could be carried without stopping all other legislation on the subject.

Within the last twelve months Sir Wilfrid Lawson and his followers have had the excellent good sense to drop the Permissive Bill, and proceed, by way of Parliamentary resolution, in favor of "local option." I really do not know exactly what is meant by "local option." Perhaps the Alliance itself does not know; the wisest course would be not to know—that is, to leave a latitude of meaning. In any case they have changed their policy. For year after year, for nearly the average length of a generation, it was the eleven clauses and one schedule of the Permissive Prohibitory Liquor Bill, pure and simple. Now it is "local option." Even if "local option" mean option of prohibition, a resolution is a more tentative method of procedure than the precise clauses of the celebrated bill. But if, as I fondly hope, "local option" will be interpreted to mean option for local authorities to regulate the liquor-traffic in the way thought to be most suitable to the locality, including prohibition when clearly desired by the inhabitants, then the matter assumes a much more hopeful aspect. Not only will the resistance to such a proposal be far less than to the Permissive Bill, but there will be considerable probability that when passed some successful experiments will be carried out. In fact, this "local option" would just be the mode of giving a wide field for diverse experiments which I am advocating. The teetotalers would be at liberty to try their experiments, but they would not in the mean time stop the progress of many other experiments, some of which might, in the course of ten or fifteen years, offer a sound solution of this most difficult problem. Of course, I am aware that this question of the drink-traffic is to a considerable extent a political one. There is a good deal which I might say upon this topic, but it would not be suitable to the tenor of my theme. If the political condition of England be such that the social reform of the people is not the main purpose of our Government, then we must hope that there are brighter lands where the political position is very different.

The best way of dealing with the liquor-trade would be to hand over the matter to the hands of a strong executive commission framed somewhat on the lines of the Poor-Law Commission. This body should have the power of authorizing schemes, proposed by local authorities, and should supervise the working of such schemes, and collect minute information as to the results. They would work entire-

ly through local authorities, whether the corporations of cities and boroughs, or the benches of Licensing Magistrates. Before allowing any very serious experiments, such as the abolition of the public sale, the local authority would have to present evidence that the mass of the inhabitants was in favor of such a measure, and the Commissioners would then probably assign a suitable district, and authorize police regulations suitable for the most advantageous trial of the experiment. This method would carry out to the fullest point the idea of a "local option." Free licensing might be tried in Liverpool, and such other boroughs as liked to venture on such a hazardous experiment. The Gothenburg scheme would be adopted by Birmingham and a few other towns. Manchester might prefer the slighter measure of a rigid restriction and supervision of the public-houses. It is to be hoped that Sunday closing and a lessening of the week-day hours would be voted by many local authorities, and the experiment of remodeling the trade, as suggested above, ought certainly to be tried I should also much like to see some trial made of the important suggestion put forward by Dr. John Watts, at the last meeting of the Social Science Association. He suggests that in each town or district a limited number of licenses should be sold by public auction or tender. His purpose apparently is to limit the number of licenses, and yet to secure the profits of the monopoly to the community.

After the expiration of ten or fifteen years, Parliament would be in possession of a great amount of really practical information, but the probability is that it would not be found necessary to pass any great act for the subsequent regulation of the traffic. The scheme which was found to work best would by degrees be imitated in the districts of corresponding circumstances, just as the Gothenburg scheme is being imitated in other Swedish towns. I do not think that in a matter of this sort the final law need be exactly uniform. In the licensing act of 1872 it was found undesirable to fix a uniform hour of closing public-houses all over the country. Owing to the difference of habits, the metropolitan area was allowed one hour later at night, and considerable latitude was left to the Licensing Magistrates to vary the hours of closing. Surely such matters approximate more in character to hackney-cab regulations or matters of police, which have long been left to the borough authorities. It is only the political question looming behind the social or legislative question, which could warrant Parliament in deciding that people shall go to bed one hour earlier in the country than in London. But Parliamentary experience concerning the Licensing Act of the late Cabinet, and the now defunct Permissive Bill, can not encourage any party to press for a further great general measure of licensing reform. As to the present state of things, it could not be much worse nor more absurd. What with the great variety of kinds of licenses, the doubts and fears of the magistrates as to their powers of withdrawing licenses or restraining extension of premises,

the remissness—to use a mild expression—of the police in prosecuting the offenses of publicans, and the universal facility of obtaining any amount of drink at the nearest grocer's shop—I say things really can not be much worse than they are. Under the vigorous exertion of local option the state of affairs would undoubtedly improve in some parts of the country; the pressure of public opinion, of the proposed Commissioners, or, in the last resort, of Parliament, would eventually force the negligent localities to follow the example of the most successful "local-option schemes."

Let it be understood that I do not for a moment suppose that there is much, if any, novelty in the proposals made above. In one place or another almost every suggestion, except perhaps that of a superintending Commission, has been made and discussed. The Lords' Committee have themselves recommended "that legislative facilities should be afforded for the local adoption of the Gothenburg and of Mr. Chamberlain's schemes, or of some modification of them." And the Lords have themselves recognized the value of social "experiments" in providing counter-attractions to the public-house. In their final report, dated the 17th of March last, they remark (p. xliv.):

> These experiments are too recent, and, in spite of their rapid increase, too partial and limited, to enable the Committee to pronounce with confidence on their ultimate success, or on the extent of the influence they may exercise in diminishing intemperance; but they desire to express their strong opinion that, if generally prosecuted and conducted with due regard for the wants and comforts of a population among whom education is gradually diffusing a taste for enjoyment far less coarse and gross than in the past, they are destined to have an important influence for good. It is obvious that the desire for recreation is felt by all classes alike.

What is this, however, but an express recognition by the House of Lords of the need of experimentation as regards the entertainment and recreation of the people? I fail to see how such experimentation either can or ought to be confined to philanthropists. If we look around and notice the vast new restaurants of London, the innumerable glittering railway-bars in all parts of the country, the music-halls of all ranks and kinds, the dancing and drinking saloons of some provincial towns—such as Nottingham—and the great enterprise with which such places of recreation as the Pomona and Bellevue Gardens at Manchester are conducted, we shall see that social experiments are not confined to the teetotalers. Indeed it would not be difficult to prove that the nugatory licensing laws, as now administered, present the least possible obstacle to the publicans in pushing their experiments, while they do prevent social reformers from interfering, or from establishing counter-experiments on an equal footing. It is hardly too much to say that the licensing laws are laws to give a license to the publicans and grocers to do what they like to extend the sale of spirituous liquors.

Although the liquor-traffic presents the widest and most important sphere for social experiment, there are many other matters to which it must be applied. Consideration in detail must show whether, in each case, the tentative method is or is not the proper method. But it is easy to name several other reforms which ought, in all probability, to be approached in the experimental manner. Thus, peasant proprietorship ought certainly to be tried in Ireland, as it was intended to be tried under the Bright clauses of the Irish Land Act. I am familiar with most of the economic objections to peasant proprietorship in this kingdom, and I have read sufficient of the large literature of the subject to know that evidence in favor of and against such a tenure of land is exceedingly divergent and perplexing. The proper resource, then, is to *try the thing*, not by some vast revolution in the land-owning of Ireland, as proposed by the late Mr. Mill—a measure which, in the first place, would never pass Parliament, and, if it did, would cost an enormous sum of money, and probably result in failure—but by a small and progressive experiment. "Earth-hunger" is a very potent passion, and I believe it is that from which the Irish people are really suffering. Bread and bacon are not the only good things an Irish peasant might aspire to; a place to call his own, a share of the air and sunlight of his native isle, and a land-bank in which to save up the strokes of his pick and spade, might work moral wonders. It is not safe to predict the action of human motive; but, at any rate, try it, although the trial cost as much as one or two first-rate ironclads, or a new triumph over a negro monarch. Surely the state of our Irish Poland is the worst possible injury to our "prestige."

Much doubt exists, again, as to whether imprisonment is necessary to enforce the payment of small debts. If needless, it is certainly oppressive. But if the abolition of the power of imprisonment, on the part of County Court judges, would really destroy the credit of the poorer classes with their tradesmen, a general measure to that effect would be dangerous and difficult to retract. I do not see how the question can be decided, except by trying the effect in a certain number of County Court districts, and watching the results.

It would be well worth the trouble to try the effect upon a certain body of inhabitants of the most perfect sanitary regulation, somewhat in the manner foreshadowed by Dr. B. W. Richardson in his "City of Hygeia." This I should like to see tried, as regards the middle classes, in some newly built watering-place, with full and special powers of sanitary regulation to be granted to it by Parliament, avowedly as an experiment. At the same time, a few large blocks of workmen's dwellings ought to be built and placed under experimental sanitary laws. I am convinced that legislation must by degrees be carried much further in this direction than is at present the case, but it ought to proceed tentatively.

One of the difficult questions of the present day is, How can Lon-

don be supplied with water? There would be few engineering difficulties if it were allowable to separate the supply of pure water for drinking and cooking purposes from the much larger quantity required for other purposes. Will people drink the impure water? Who can decide such a question satisfactorily, except by experiment on a moderate scale? What could be more absurd than to spend millions upon procuring a separate supply of pure drinking-water for the population of London, and then finding that the population would drink the impure water? Many other like matters must be referred to trial, but it is not the purpose of this article to present a catalogue of experimental reforms, or to follow the argument out into all the possible details.

I am well aware that social experiments must often be subject to various difficulties, such as the migration of inhabitants, or even the intentional frustration of the experiment by interested parties. I have heard it said that the prohibition of liquor-traffic could not be tried on a small scale, because the publicans would be sure to combine to send liquor into the area. If they did so, the fact could readily be put in evidence, and, if they can defeat the teetotalers in detail, I am quite sure that they will defeat them upon any very great and general measure like the Permissive Bill. As to migration of inhabitants, it must be provided against either by suitably increasing the areas of experimental legislation, or else by collecting information as to the amount and probable effects of the migration. But the main point of my theme is to prove that we can not really plan out social reforms upon theoretical grounds. General argument and information of all kinds may properly be employed in designing and choosing the best experiments, but specific experience on a limited scale and in closely proximate circumstances is the only sure guide in the complex questions of social science. Our method must be that of the supremely wise text: "Prove all things; hold fast that which is good."—*Contemporary Review.*

CURIOUS WAYS OF GETTING FOOD.

By HERMAN L. FAIRCHILD.

TO eat and to be eaten would seem the necessity and the end of every living thing. Doubtless every plant may serve as food for some animal; and there is no animal which may not be meat for some other animal. Nature is a vast hunting-ground, where man and beast and every animated being are legitimate prey. Not alone do the carnivorous animals eat the herbivorous. The blood-loving tiger is itself the prey of parasites. Even proud man is living booty. Animals within animals; life within life. There is literal truth in the satirical passage:

"So, naturalists observe, a flea
Has smaller fleas that on him prey;
And these have smaller still to bite 'em,
And so proceed, *ad infinitum*."

The variety of animal food is, therefore, as broad as animated nature. Hence, we find great variety of means and methods for procuring subsistence. Particularity in food implies especial or efficient means of getting that food. The strange appendages of animals, their form, color, and habits, have to do more with the prehension of food than with any other function. It will be interesting to briefly survey the animal kingdom with reference to this marvelous adaptation. Its origin we will not discuss.

The simplest manner of procuring food is shown by the tapeworm and some other intestinal animals. These feed on the nutritive fluid prepared in the alimentary canal of the animals which they inhabit; and, being destitute of mouth and stomach, absorb the already digested food directly through the skin or body-walls. Probably this absorption does not require will or effort on the part of the parasite, but takes place simply by the physical action known as *osmose*. It is thus equivalent to the last step in the digestive process of higher animals. Some parasites, as the larva of the tapeworm, which live in the muscles and tissues, imbibe the animal juices by the walls of the body; but here the process as a whole is slightly higher, for this food probably requires more elaboration or digestion.

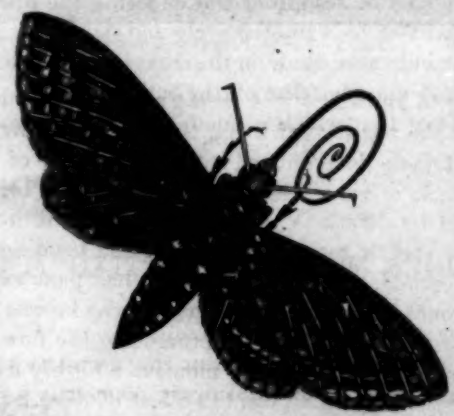

FIG. 1.—HAWK-MOTH (*Sphinx quinquemaculatus*).

Any special modification or organ for procuring food is a great advance beyond the method already described. Liquid food is more easily prehended than solid, yet the means are various and remarkable. Even the simplest organs are wonderful in their structure and action.

Those butterflies and moths which take any food at all have a

long, slender tube for pumping the nectar of flowers. This "proboscis" is frequently much longer than the insect's body, and when not in use is beautifully coiled under the head. The humming-bird has a long, slender beak for the same purpose, which in some species is curved to fit certain flowers, it is said. Bees and flies lap their food, the former with a hairy tongue, the latter with a proboscis knobbed at the end. The sucker of the leech is furnished with three little saws for cutting the skin of its prey in order to draw its blood. A barbed tube is used by the louse; while the irrepressible mosquito is provided with a whole set of surgical instruments. Its proboscis, which seems so simple to the unaided eye, is found to be a "flexible sheath inclosing six distinct pieces, two of which are cutting-blades or lancets, two notched like a saw with reverted teeth, a tubular canal, and the central one an excessively acute point, which is also tubular."

FIG. 2.—MOUTH-PARTS OF MOSQUITO.

It is interesting to know how the insect uses so many instruments, as we have all had the pleasure of being the subjects of her surgical skill (for only the female is admitted to the practice of bloodletting). "When the attack is made, the gnat (or mosquito) brings the tip of the organ within its sheath to press upon the skin into which it presently enters, the sheath remaining without and bending into an angle as the lancets descend. When the weapon has penetrated to its base —a distance of one sixth of an inch or more—the lancets move laterally and thus cut the flesh on either side, promoting the flow of blood from the superficial vessels; at the same moment a highly irritative fluid is poured into the wound, which has the effect of diluting the blood and thus rendering it more capable of flowing up the slender central tube into the throat of the insect."

Many aquatic animals, especially the low, fixed forms, depend for subsistence upon the minute organic particles floating in the water. But if the animal can not move in search of food it must have some means of bringing the food to itself. This is frequently accomplished by vibrating hair-like appendages, called cilia, which produce currents

in the water. In that immense aggregation of minute animals, the sponge, the canals ramifying through the mass are lined with cilia, which cause constant currents of water to pass in at the small pores and issue at the large openings. Thus "the sponge represents a kind of subaqueous city, where the people are arranged about the streets and roads in such a manner that each can easily appropriate his food from the water as it passes along." Cilia fringe the gills of the bivalve mollusks, like the oyster and scallop, or the clam, which can burrow in the sand and send up into the water a long tube or siphon.

The great Greenland whale subsists on the small animals which swarm in the Arctic seas. But how shall the enormous beast capture sufficient of those tiny creatures? Its apparatus is as remarkable as it is unique—a huge sieve, made of the fringed edges of hundreds of "whalebone" plates, hanging from the roof of the mouth. Filling its cavern-like mouth with water containing the small animals, these are strained out as the water is expelled.

Solid food in mass requires some means of grasping—true prehension; generally accompanied by the power of dividing or crushing—mastication. A most curious method, and but one step higher than shown in the tapeworm, is exhibited by the microscopic amœba, found in fresh water. An animal without any permanent appendages whatever, a bit of almost structureless protoplasm, it nevertheless moves without limbs, breathes without gills, seizes food without prehensile organs, and digests without a stomach. All the animal functions are performed by the general mass of the body. Its mode of feeling is as follows: When a nutritious particle comes in contact with the body, the surface at that point begins to depress or fall in, and so continues until the surrounding surfaces meet and unite. In other words, the animal wraps itself around the particle, and the bit of food is enveloped in the albuminous body-mass. The nutritive matter is absorbed, and any undigested or waste matter is expelled by a reverse process. Briefly, the amœba extemporizes a stomach upon the place and at the time it is needed, and is not troubled with that uneasy organ when it is not needed. The ills of dyspepsia are to the amœba unknown.

The polyp or sea-anemone has numerous grasping arms called tentacles surrounding the mouth, which is at the top of the stump-shaped body. But the muscular power of the soft, watery animal is not sufficient to hold a lively crab or other struggling prey. To supplement this weakness, it is provided with a most marvelous and deadly apparatus. The surfaces of the tentacles, and frequently of the stomach and body-walls, hold countless minute sacs containing beautifully coiled filaments, which are quickly thrown out like so many poisoned darts to pierce and paralyze the victim. The structure and action of these stinging threads is one of the greatest wonders of nature. The weak jelly-fish uses the same means to overpower its prey, which, enveloped and paralyzed by the hundreds of thread-like tentacles, is drawn up-

ward into the digestive cavity. The larger jelly-fishes, with tentacles streaming out to a length of thirty or forty feet, could easily paralyze large animals. It has been suggested that some of the sudden and strange disappearances of bathers may have been caused by these fearful creatures.

Hundreds of little air-pumps are employed by the star-fish. These sucking-disks upon the under side of the flexible rays enable the animal to adhere with surprising power. And it can also protrude its stomach to inwrap prey which is too large to swallow. It is thus able, by turning itself inside out, to suck an oyster from its shell; and, having an especial fondness for these mollusks, it makes great havoc among the oyster-beds.

The tongue is the prehensile organ of the univalve mollusks. Being covered with rows of toothed plates it acts like a rasp, or can be protruded beyond the head to serve as a drill. The vegetable-feeding snails have also a bony plate in the roof of the mouth to aid in cutting. The common garden-snail has not less than 28,000 teeth on its strap-shaped tongue. These mollusks, and all animals hereafter mentioned, have the superior power of vision which, enabling them to discover food or pursue their prey, is of the greatest aid in getting food. The other senses are also aids to prehension.

FIG. 3.—COMMON POULPE (*Octopus vulgaris*).

The devil-fish, so called, the highest of mollusks, is possessor of an apparatus which for terrible efficiency could hardly be surpassed. Its prey is seized by eight long "arms" which surround the mouth, and the grasp is assured by rows of sucking-disks on the inner side of these arms. Indeed, these diminutive air-pumps hold so firmly that an arm will sometimes tear from the head. Some species have in addition two other arms equaling the body in length, which are commonly folded beneath the head, out of the way. As the creature nears its intended prey, these two long arms are quickly projected and seize the

victim by means of the suckers, thus serving a purpose similar to a harpoon or lasso. As the victim is drawn nearer, the shorter arms wrap around it and effectually prevent its struggles. Now comes in play another instrument, its powerful, horny jaws, which form a beak shaped like a parrot's inverted. With this terrible weapon it bites its victim in the back of the neck, thus cutting the spinal cord and producing immediate death.

FIG. 4.—PROTRUDED ŒSOPHAGUS OF A SEA-WORM.

How different is the method employed by the Laodicea! This worm inverts or protrudes its gullet as a sort of proboscis, provided at the end with little teeth for grasping. Like the star-fish, to seize its food, it turns itself inside out.

Biting insects and most articulates have horny jaws moving horizontally. Poison fangs are sometimes added, as in the centiped. The claws of the crab and lobster are transformed legs; one frequently used as an anchor, while the other holds the prey.

Every one is familiar with the skillful trap which the spider sets for his victims. This wily creature sometimes builds a concealed lair whence it can spring upon its prey. Others, that spin no web, have a curious fashion of fastening a thread to whatever object they stand on at the instant they pounce on their prey, in order that the victim,

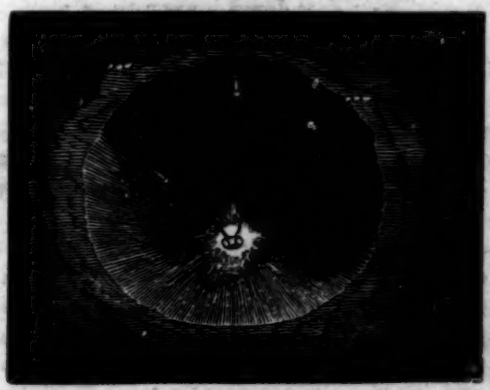

FIG. 5.—PIT OF ANT-LION.

which is frequently larger than the spider, may not fly away with its captor. It does fly to the extent of the thread, but the poison soon takes effect, and the cruel spider deliberately winds up its anchor cable and recovers its footing.

A relative of the dragon-flies, the ant-lion, when in the larval state, digs a conical pitfall, at the bottom of which it lies buried, with only its strong jaws projecting. Here it patiently waits for an ant or some small creature to tumble in. If the struggling animal seems likely to clamber out, the ant-lion hurls sand at it to bring it within reach of the fatal jaws, where it is surely lost.

Ants sometimes undertake the dairy business. Being exceedingly fond of a milky fluid which exudes from two tubes situated on the hinder part of the bodies of certain plant-lice, called aphides, to procure it they resort to measures strangely intelligent for even the proverbially wise ant. They have been known to build mud stables in which the aphides were kept as stalled milch-cows. To cause the flow of milk, the ants irritate or rub the tubes with their antennæ.

FIG. 6.—ANT MILKING AN APHIS.

With few exceptions fishes depend upon their numerous teeth for seizing food. The sturgeon is toothless, and draws in its food by suction. A single long tooth is used by the hag-fish to transfix its victim, while it bores the flesh with a long, spiny tongue. The angler lies half concealed by sand and weeds, with its enormous mouth agape ready to seize any small fish which may incautiously venture near. Upon its nose is a long, flexible spine, with shiny tip, which, waving in the water, decoys small fry to their death.

King of fishes, by virtue both of size and ferocity, is the rapacious shark. This terror of the sea has its mouth armed with hundreds of teeth, triangular in outline and serrated on the edges. There are several rows, and, as the outer old teeth drop away, others rise into position to take their places.

In Japan is found a beautiful fish which has a sort of gun for bringing down insects. It does not have to wait, like other fishes, for the fly to fall into the water by accident. Seeing one lighted near the water, the chætodon gently approaches, and, aiming its beak, blows a drop of water with unerring aim, knocks the unsuspecting fly off its perch into the stream, and devours it, doubtless with a relish begotten

of its skill as a sportsman. An air-gun with a drop of water for a bullet! It is said the Japanese amuse themselves by watching their captive chætodons shoot the flies presented to them.

Fig. 7.—The Angler (*Lophius piscatorius*).

Most reptiles use teeth for prehending food, like the fishes. Some, however, as the toad and chameleon, employ the tongue, which, being rooted in front and free behind, besides being very extensile, is thrown out and over with great quickness and precision. A sticky saliva causes the insect to adhere.

Poison-fangs of serpents are helps to procure food as well as weapons; and the power of charming is a very strange and effective way of obtaining food.

The alligator will approach a large animal which may be standing at the water's edge, and, by a quick blow of its powerful tail, knock the unsuspecting creature into the water. In deep water it is at the mercy of the reptile, which kills it by drowning. The nostrils of the alligator and crocodile are so placed as to be out of water, while the prey held in the jaws is beneath the surface.

Birds have not great variety of organs or methods of prehension. Beaks, claws, tongues, and keen senses complete the list of means. The woodpecker drills a hole into the tree to secure the larva which by some myterious power it knows is buried there; and its barbed tongue is used to draw the worm from its hole. The slender, forked tongue of humming-birds is used to grasp and draw minute insects from the depths of flowers. The long beaks of some birds are used to penetrate the sand or mud in search of worms. Birds of prey grasp

with their talons. Their sight is wonderful, enabling them to discover their quarry at a great distance, and to strike it without error, notwithstanding the velocity of their approach. The sense of smell would seem remarkably developed in certain carrion-eating birds. The secretary-bird kills the poisonous serpents which are its diet by kicking them, while our domestic fowls scratch for a living.

FIG. 8.—TONGUE OF WOODPECKER.

In variety of prehensile means mammals far surpass any equal group of the animal kingdom. Owing to our familiarity, however, these peculiarities seem less interesting; but, if we could divest ourselves of preknowledge, or see them with a new vision, we should be astonished and delighted by the various contrivances and the curious adaptations. The tongue is the chief or only prehensile organ of many animals. Here belong the ox and all the cud-chewers. Of these the giraffe is the strangest. Intended to browse, it has an extremely long neck, mounted on equally long legs and shoulder-blades; yet, lest it should still fail of reaching its dinner, the tongue is proportionately long and remarkably prehensile; being able to select the sweetest foliage, or extend so slenderly at the tip as to enter a hole the size of a quill. Its lingual dexterity is sometimes exercised to the discomfiture of visitors at the menagerie. The toothless ant-eater breaks down the hard mounds of the ants or termites with its powerful claws, and sweeps the insects into its mouth with an immensely long, worm-like tongue; or it may thrust the tongue directly into the ant-holes. The insects adhere by means of a glutinous saliva, as in the case of the toad.

The hog uses his nose for getting food, and the star-nosed mole has a similar contrivance. The lips are employed by the horse; and we find both nose and upper lip prolonged as a proboscis in the tapir and shrew. But the elephant is, of course, the great example of immense proboscis. The whole make-up of the animal is queer, and to a stranger would be absurd. The small boy who described the elephant as "a large beast with a tail at both ends" had the elements of a naturalist. As the neck of the huge creature does not permit great motion of the head, the trunk supplies the deficiency. The tusks are also chiefly food-gatherers; used as picks and spades for uprooting trees and digging succulent roots. The tusks of the walrus are certainly locomotive and defensive organs, but it is suggested that perhaps they are also used to raise algæ from the rocks of the sea-bottom.

The greater number of mammals depend wholly upon the jaws

and teeth for grasping food. A full description of these organs more properly belongs to the subject of eating food. Gnawing animals, like the rabbit, have the four front teeth, incisors, acting as chisels. In the hippopotamus the prehensile teeth form tremendous shears for cutting plant-stems.

Beasts of prey use jaws or feet, or both ; but, to bring the prey within reach of either organ, requires keen senses to discover, and

Fig. 9.—The Mammoth, or Hairy Elephant.

craftiness and speed to catch them. Animals of the dog tribe seize with the jaws ; those of the cat tribe use all four feet. The supple paw, with its retractile claws, is highly fitted for grasping and tearing, as well as for silent, stealthy tread. The cat's tongue is armed with spiny, recurved papillæ, to lap blood or scrape flesh from bones.

Monkeys also employ all their feet for grasping ; and, in common with those mammals that can sit on their hind-limbs, such as the squirrel, rat, kangaroo, and bear, carry food to the mouth with the fore-limbs ; and some monkeys use the sensitive tips of their long tails to draw fruit from crevices or holes. The strainer of the Greenland whale has been described. A shovel-bill is the appliance of the duck-mole.

Only reference can here be made to the adaptation of mammals to the element in which their food exists. The whale, seal, hippopotamus, and duck-mole, find sustenance in the water. In the ground burrows the mole ; the squirrel and sloth inhabit the trees, while the bat searches the air. Thus every element contains representatives of this highest animal group.

Prehension of food is so various in means and methods that no universal laws regarding it can be formulated. It can not form a basis of classification, seeming to have little or no discovered relation to animal rank. However, the subject is of greatest interest ; and,

together with the adaptations of animals in other directions, has received in recent years much merited attention, chiefly in behalf of development theories. But, whether these remarkable adaptations of animals to peculiar food and surroundings be the result of variation and development, or of special creation, they are equally wonderful.

THE PLEASURE OF VISUAL FORM.

By JAMES SULLY.

I.

IT is often said that the pleasure of form as contrasted with that of color is an intellectual pleasure arising from the perception of relations (unity in variety, proportion, etc.). In a sense this is true, for, as I hope to show in the course of this essay, the appreciation of form as compared with the enjoyment of color is saturated, so to speak, with the more refined sort of intellectual activity. But the fact that certain varieties of the arts of form, more especially outline drawing, dispense with the pleasure of color, and even with that of light and shade, suggests that the pleasure of visual form includes a sensuous element as well as an intellectual. It will be my special aim in this paper to bring out this somewhat neglected factor in visual gratification, and to indicate, so far as it is possible, its importance among the several factors, which together compose what we call beauty of form.

In pursuing this inquiry, it will be best to disregard the sensuous enjoyment of light and shade. For our present purpose, differences of light and shade are merely means of appreciating form. Again, it will be advisable to include all varieties of form as determined by the three dimensions of space. It is true that beauty of form, so far as it rests on purely visual feelings, is largely that of surface relations or of space in two dimensions. Yet it will be found to be practically impossible to treat of this apart from that other kind of beauty of form which embraces the charm of distance and perspective, and the characteristic attractiveness of solid shapes. As to the order of treatment, I shall set out with the elements of pleasure which are obviously direct—that is, arise from the activity of the visual organ—and trace the process of building up a more complex intellectual gratification on these. After that I shall pass to the indirect or associated elements of enjoyment. The simplest kind of visual appreciation of form is that of linear relations. For reasons to be spoken of presently, a straight line is the natural element of visible form, and the development of the visual perception of form (regarded as independent of that of the tactual) proceeds by a kind of synthesis of linear

elements. We may therefore confine ourselves for the present to this kind of form-intuition.

There are two ways of perceiving a line: either the eye may move along it, and appreciate its direction, length, etc., by the aid of movement; or it may fix the line, and estimate it by means of the impressions it simultaneously makes on different retinal elements. I shall assume here what is held by German writers like Lotze, Helmholtz, and Wundt, as well as by most English psychologists, that the former is the earlier method. This, then, is the simple experience into which we have first to look for the germ of the enjoyment of form.

A. Sensuous Factor.—We must imagine the eye, and first of all one eye apart from the other, moving as it now does, but having, instead of an extended retina, a single sensitive point at the center of the yellow spot, which is successively directed to different points in the outline of an object, with no other change of feeling than that which is connected with the movement itself.* It is plain that this experience will exactly resemble that of following a moving object, as a shooting star, with the single difference that in the former case the rapidity of movement will be a matter of choice. In order to understand the kind of æsthetic experience which the eye would have under these circumstances, it is necessary to say a word or two about its mode of action. I shall suppose that the reader is acquainted with the general features of the mechanism of ocular movement, and content myself with specifying one or two facts having an important bearing on our subject.

First of all, then, I would remind the reader that, setting out from the natural or "primary" position in which the axis or center of vision is directed to a point immediately in front of it, the eye is able to follow any line in the supposedly flat field of vision without a great expenditure of muscular energy, and with a uniform action of one or more muscles.† In other words, it is the simple and normal mode of visual action to describe a movement which answers to a straight line on the flat field. But, though all rectilinear movements from this primary position are normal ones, some are easier than others. Thus, while horizontal movements only require the action of one muscle, vertical movements involve two, and oblique movements three.‡ Movements far away from the primary position to points near the periphery of the field clearly involve a greater degree of muscular expenditure, the muscles in this case being contracted to their extreme limit. Further, it is noteworthy that in these outer regions of the field movements are no longer executed with the same simplicity. Thus, if the eye follows an horizontal line lying high in the plane of vision, more

* This supposition is not really conceivable, since a plurality of retinal elements is necessary to the eye's *following* any line.

† In this primary position the tension of the antagonist muscles is just balanced, and movement involves the first and easiest stages of contraction and relaxation.

‡ See Wundt, "Physiologische Psychologie," pp. 536–539.

than one muscle is involved. To sum up, the eye, owing to the laws of its mechanism, follows a line much more easily in the central than in the peripheral parts of the field, and in the central parts it follows a vertical line more easily than an oblique, and an horizontal more easily than a vertical.

It would seem to follow, from these conditions of facile movement in monocular vision, that in the case of binocular vision movements with parallel axes will be easier than movements with convergent axes. And this is proved by observation, for, as Wundt points out, infants instinctively move their eyes in the former way. Combined movements with convergent axes constantly involve an extra element of muscular tension, namely, that which is required to counteract the natural tendency to parallelism.* For the rest, it is to be noted that, with respect to "movements of convergence" (which cause the axes to approach one another, or *vice versa*), the symmetrical movements, which would be executed in following a receding line in the medium plane of the body, have so far a natural superiority over asymmetrical ones that, in the former case, the movements of the two eyes are exactly similar, in the latter case not so. The greater sense of ease which accompanies such symmetrical movements is probably explained, in part at least, by the constant need of executing such movements in passing the eyes from near to distant points lying in this medium plane.

Let us now pass to the subjective aspects of ocular movement. Although there is still a good deal of uncertainty respecting the exact composition of the feelings of movement, it may be taken as fairly proved that they include an active element or "feeling of innervation," which is correlated with the central excitation of motor fibers, and a passive element or tactual sensation which is connected with a reflex excitation of sensory fibers, consequent on certain differences in the tensions and mutual pressure of various parts of the skin which result from the movement.† The recognition of this twofold element in the feelings of movement may help us in understanding the pleasures of ocular movement.

It will, I think, be admitted as a truth, which is both borne out by direct experience and deducible from more general principles, that every movement of an organ is accompanied by at least a slightly pleasurable feeling, provided it has an appreciable duration and rapidity, and on the other hand is not excessive, whether as violently rapid, or as unduly prolonged in time, or repeated, or, finally, as unduly pro-

* It is to be added, however, that in the case of movements with convergent axes, directed to a point immediately in front of the two eyes, the contrast between horizontal and vertical movements, pointed out in the case of monocular vision, seems to be somewhat modified, though hardly obliterated.

† It is probable that this passive element includes the mental concomitant of an excitation of the sensory fibers which are known to run to the muscles themselves.

longed in space, or carried beyond the limits of ordinary and easy muscular contraction. The movements of the eye will be found to illustrate this law, though, owing to the small caliber of the ocular muscles, both the enjoyment and the fatigue attending them are apt to seem insignificant quantities. The pleasures of ocular movement are thus confined within definite limits, namely, a certain duration of a certain velocity of movement over the central part of the field of vision. Further, movements involving a higher degree of muscular expenditure grow fatiguing sooner than others, as we may see in the case of following the outline of very near objects with convergent axes. Finally, certain combinations of muscular action give rise to fatigue sooner than others, e. g., those necessary to oblique movement sooner than those involved in vertical or horizontal. The reason of this may be not so much the larger number of muscular factors as the relative infrequency of the combination. We have in a general way much more need to execute vertical and horizontal movements than oblique ones, height and lateral distance being the two most important dimensions; and this would tend to make the former easier and less rapidly fatiguing. For a like reason, the superior ease of horizontal movements may be referred in part to the greater need in general of attending to lateral relations of distance than to vertical ones.

Within these limits of pleasurable ocular movement we may find a difference in the quality of the enjoyment, according as the movement is energetic (though not excessively so) or comparatively restful. In the first case the feeling is of a more active and stimulating quality, and approaches in character the sense of power which we experience when we employ the larger muscles of the body. In the second case the feeling is more passive and allied to sensation proper. It may be thrown out as a conjecture that the former mode of pleasurable feeling is connected with the excitation of the motor fibers, whereas the latter consists mainly of the tactual and other sensations already referred to. We may, perhaps, conceive that, when the motor innervation reaches a certain degree of intensity, its mental correlative becomes the predominant feeling; but that, when it falls below this point, the passive sensations, come to the surface of consciousness, so to speak, and give the dominant character to the feeling. On the whole, the gentler forms of ocular movement yield richer enjoyment than the more energetic. The muscles of the eye hardly seem to be of a sufficient caliber to supply the full consciousness of active force, which is a concomitant of the energetic action of the larger muscles of the body. Hence it may be said that the quieter forms of motor enjoyment are preferred by the eye.

This difference in the quality of the agreeable feelings of ocular movement is best seen in comparing slow and rapid movements, as in following the progress of a rocket in its early and later stages. As Professor Bain remarks, rapid visible movements are stimulating, while

slow ones are more voluptuous and allied to the richer varieties of passive sensation. In following straight lines, and in tracing the outlines of objects, the eye has, it is obvious, a choice out of an indefinite number of velocities of movement. It is probable, for the reason just given, that under these circumstances it usually prefers a slow to an excitingly rapid species of movement.*

For a similar reason those directions of ocular movement which answer to easy and habitual muscular action, have more of a pleasurable character than those which soon approach the threshold of fatigue. Thus, an horizontal line is, as a rule, in itself, and apart from any extraneous consideration, more enjoyable, because more restful, than a vertical. Let the reader compare the feelings he has in looking at architecture, in which the vertical direction predominates, and at the approximately horizontal lines of a flat landscape. A somewhat analogous difference exists between movements of the two eyes with strongly converging and with parallel axes. The sweet repose of distance arises in part from this comparatively relaxed form of muscular activity.

So much as to the pleasure of single ocular movement. Let us now see how a pleasant succession of movements is to be secured. The conditions of agreeable sequence of movement seem to be the combination of the refreshing and stimulating element of change with an element of smoothness or ease of transition. Change of movement is, of course, necessitated by the universal condition of mental life, and variety is the very essence of all æsthetic experience, all monotonous feeling being wearisome. On the other hand, a chain of varied movements may be smooth and agreeable, or jerky and harsh, and this difference is related to the innate mechanical conditions of movement, and to the effects of habit.

Change of movement may most easily be secured by a variation either of velocity or of direction.† One and the same movement may vary in velocity, as in watching the ascent or descent of a projectile thrown up vertically. So different movements may present a difference of velocity as in the sequences of a ballet. Such contrasts plainly answer to the most favorable mode of expending motor energy. Again, our movement may be followed by another of different direction; that is to say, one that involves the action of fresh muscular elements, or a change in the relative amounts of action of two or more combining muscles. All complicated movements of objects and all arrangements of lines in the figures of bodies supply such variation in abundance.

So much as to change of element. Let us now pass to the other condition of agreeable sequence, namely, smoothness. The first and

* A certain rapidity is no doubt made natural by the need of visually construing objects as wholes.

† Change of duration and extent of movement will be best spoken of later on.

most obvious way of realizing such smoothness is by reducing the degree of change or contrast to a minimum. In this way we get a gradation of movement either in respect of velocity or of direction.

Gradation in direction or velocity, like gradation in shade of color or pitch of tone, is attended by a peculiarly agreeable feeling. One and the same movement may exhibit a gradual rise and fall of velocity, and it is probable that this is the form of movement naturally produced by all muscular contraction. Gradation in direction, which is at the basis of all curvilinear movements, depends on a gradual alteration in the relative degrees of activity of two or more muscles, and so corresponds to gradation in color or tone, which is supposed to rest on a continual increase of activity in certain nerve-elements, and decrease in others. A mode of gradation somewhat similar to that in direction is experienced in symmetrical movements of convergence, and especially in moving the axes from a near to a distant point, and so gradually relaxing the tension due to convergence.*

This mode of motor enjoyment is realized when standing in the middle of a building or an avenue of trees, and tracing an imaginary central receding line, and it is noticeable that we naturally place ourselves in the position and execute this kind of movement whenever we wish to appreciate the effect of perspective. It may be added that a union of gradation of velocity with that of duration, as in tracing the path of a projectile across the field of vision, affords the eye its richest form of motor delight.

A graduated series of movements allows of the least exciting degree of the feeling of variety. If a more powerful effect of change is desired, the element of smoothness must be looked for in another way. A succession of different movements has a certain degree of smoothness if they are continuous and free from sudden pauses and jerkiness. This can only happen if the movement is continuous in time, and, what is implied in this, in space—that is to say, the second movement must be one which can be commenced in that position of the eye in which the first has left it. Where this is not the case, there must be a "spring," so to speak, of the eye, to the new starting-point, which counts as an appreciable element of roughness or unevenness.

A higher degree of fluency is attained when the muscles, successively employed, are organically connected one with another, whether by some innate arrangement or by the influence of habit. This applies more especially to the action of the antagonists. A movement of the eyes to the left of the field produces a tendency in the antagonists to pull them back again. Hence the natural disposition to trace

* A rectilinear movement of the eye away from and back to the primary position may be said to afford a faint feeling of gradation, analogous to that experienced in movements of convergence.

a line forward and backward. Assuming the primary position to be the natural one, we may argue that any movement of the axis of vision from the center of the field excites a tendency to a corresponding movement of return to the central point of repose. Any chain of visible movements, as those of a ballet, and any arrangement of lines will gratify the eye in proportion to the number of such balancing actions of the ocular muscles which it includes.

It is only one step more to say that a full degree of fluency of movement implies a simple rhythmic order in the successive movements. The muscles of the eye being symmetrically formed, it follows that the action of any one will be compensated by the action of another of the same duration (the velocity being supposed to be the same). In this way a certain amount of rhythmic or equal time-order is rendered agreeable by an innate organic arrangement, and quite independently of any conscious perception of time-relations.

And here we reach the limit of what can be called the organic factor of sensuous gratification in ocular movement, and trench on the properly intellectual enjoyment of perceived relations. The perception of proportion would no doubt be possible if the eyes were what we have so far imagined them to be—incapable of simultaneous impressions. The moving eye, like the moving limb, can appreciate relations of duration and of distance or time-rhythm and space-rhythm within certain limits. Yet such a coördination of successive elements would be certainly inferior to that of the actual eye, with its capability of simultaneous impressions. It would probably be inferior to the ear's perception of measure. Hence we shall do best to treat of the visual sense of proportion and equality of magnitudes in connection with that more complex organ with which nature has actually endowed us. To the consideration of this higher kind of perception let us now pass.

B. Intellectual Factor.—In endowing our imaginary eye with an extended retina which allows of simultaneous perception of form relations, we do not get rid of the elementary experiences of movement first dwelt on: we only transform them somewhat. There is good reason to think that actual movement enters into our customary perception even of smaller forms much more than is generally supposed. It may be added that what we call a simultaneous perception of form is often, as I shall have occasion to show presently, a sequence of simultaneous perceptions. But more than this, one may now contend, with a fair degree of confidence, that, even in the perception of form by the resting eye, motor elements are essential ingredients, however much they may be disguised.

I need not here expound or defend the hypothesis of local signs put forth by Lotze, and accepted with certain modifications by Helmholtz and Wundt. My concern here is to trace some of the æsthetic consequences of this hypothesis. It at once follows from this theory

that the resting eye's perception of form consists of a mass of motor feeling ideally represented. In other words, it is made up of a number of imperfectly distinguished imaginations of movement in different directions, etc. And these representative feelings are very various in character, since we are vaguely aware that any fixed line, for example, offers a choice of movement in two directions, and of an indefinite number of velocities. Now, if we conceive that the feelings of movement thus represented in a confused aggregate are distinctly pleasurable ones, it must follow that such a condition, of what I may call the motor imagination, will be a highly agreeable one. It will involve a vague consciousness of a wealth of motor experience and a rich area of selection. It has been said that the possibilities of enjoyment in valuable possessions, as wealth and friends, often count more than the amount of actual enjoyment we are ever likely to get out of them. This remark may apply to that recognition of the possibilities of pleasurable movement which every beautiful form supplies to the resting eye.

The capability of simultaneous local recognition by the eye would seem in this way greatly to enrich its enjoyment of form. Our appreciation of a beautiful line includes a transition from a state of actual movement with its definite motor feelings to a state of actual repose with the imagination of movement only, and of relatively indefinite feelings of movement.

To verify these deductions, it would be necessary to show that all agreeable forms, up to the most beautiful, do answer to pleasurable ocular movements. In a general way this will be found to be so. A beautiful figure is one which selects such elements of form, together with combinations of these, as supply the eye with the more agreeable varieties of motor experience already spoken of. The selection of curved lines, the preference for horizontal lines (which seems to be exemplified in the feeling for bilateral symmetry), the taste for continuous forms or contour arrangements, for the grouping of parts about a center and for symmetrical balance (which answer no less to the natural conditions of easy movement than they do to the arrangements of the retina itself), all this seems to show how closely beauty of form is conditioned by the laws of agreeable movement.

At the same time, what we call a beautiful form is sometimes ready to sacrifice this pleasure of movement; and it does so just because it can command another kind of gratification—namely, an intellectual pleasure in the recognition of relations. To this new factor we may now pass. I have already remarked that the moving eye, capable of successive experiences only, would not attain to any very complex perceptions of relations of parts. The capability of the eye in the delicate discrimination of shades of direction and distance, and still more in the coördination of manifold details under some aspect of unity, seems to be inseparably bound up with the fact of simul-

taneous retinal impression. A word or two will perhaps make this clearer.

The substitution of simultaneous retinal perception of form for successive perception has the effect of bringing together the terms of the relations of variety and contrast, unity and similarity, under what is approximately one act of attention. If we watch the movements of a painter's hand as he draws the outline of a human figure on a canvas, our eye may attain a rough perception of the successive directions and distances; but how vague will this perception be as compared with that which we instantaneously obtain when the artist moves away from his canvas, and shows us these as parts of a permanent coexistent whole! In the former case we had to bring together by the aid of memory a number of impressions occupying some appreciable time: in the latter these were presented to us in one and the same instant. It must follow, then, that the perception of all relations, whether of dissimilarity or similarity, will under the circumstances become more definite and more exact.

Nor is this all the gain. The addition of simultaneous retinal appreciation introduces a new and finer standard in estimating the elements of form themselves. In the case of two lines, for example, which are nearly equal, or of two lines which are nearly parallel, the discrimination of magnitude and direction is finer when the lines are brought together and simultaneously perceived by help of the retinal impressions than when they are so situated that they (or their distances from one another) have to be successively estimated by the moving eye. It may be thought that these more delicate estimates are of more importance in science than in art; yet even in the latter the less obtrusive charms of form, more particularly that of the human face, involve this finer retinal appreciation. It may be added that, even when the former is too large to be easily taken in by the eye at rest, the retinal capability of simultaneous perception greatly assists in the clearer and more exact appreciation of relations. In estimating, for example, the symmetry of a tapering column, of a pyramid or of a human figure, the eye need not pass over the whole of the contour. It is sufficient if it describe a path answering to the axis of the figure; for in this case the perfect equality of any two opposed parts will be estimated by retinal perception, and the whole intuition of form will then consist of a series of simultaneous perceptions.

THE CRAYFISH.*

By Professor E. RAY LANKESTER.

"COMMON and lowly as most may think the crayfish, it is yet so full of wonders that the greatest naturalist may be puzzled to give a clear account of it." These words from Von Rosenhof, who in 1755 contributed his share to our knowledge of the animal in question, are cited by Professor Huxley in the preface to the careful account of the English crayfish and its immediate congeners, which forms the latest volume of "The International Scientific Series." The book is not designed for "general readers," those somewhat luxurious but presumably intelligent persons for whom so much scientific knowledge is chopped and spiced at the present day. It is, as we gather from the author's statement, intended as an introduction to serious zoölogical study, for those who will turn over its pages, crayfish in hand, and carefully verify its statements as to details of structure with scalpel and microscope. To these and also to those who are already well versed in crustacean anatomy, the book will have great value and interest; to the latter more especially, as showing how in the careful study of one organism we are "brought face to face with all the great zoölogical questions which excite so lively an interest at the present day," and as an exhibition of that "method by which alone we can hope to attain to satisfactory answers of these questions."

A crayfish is treated in this volume from the point of view of "science," and in the first pages we have some excellent observations (recalling earlier remarks of the author's in the same sense) directed to clearing up that mystery which good people will insist on throwing around that ever-more-widely-heard term. "Common sense," says Professor Huxley, "is science exactly in so far as it fulfills the ideal of common sense; that is, sees facts as they are, or, at any rate, without the distortion of prejudice, and reasons from them in accordance with the dictates of sound judgment. And science is simply common sense at its best, that is, rigidly accurate in observation, and merciless to fallacy in logic." In the preceding quotation, Professor Huxley is (in a legitimate and intelligible way) using the word "science" in place of "that quality of mental activity by which science is produced." Immediately afterward he speaks of science as the product of certain mental operations, in a passage which possesses great beauty while setting forth fundamental but neglected truths as to the source and scope of human knowledge. "In its earliest development knowledge is self-sown. Impressions force themselves upon men's senses

* The Crayfish: an Introduction to the Study of Zoölogy. By T. H. Huxley, F. R. S. New York: D. Appleton & Co.

whether they will or not, and often against their will. The amount of interest which these impressions awaken is determined by the coarser pains and pleasures which they carry in their train or by mere curiosity; and reason deals with the materials supplied to it as far as that interest carries it, and no further. Such common knowledge is rather brought than sought; and such ratiocination is little more than the working of a blind intellectual instinct. It is only when the mind passes beyond this condition that it begins to evolve science. When simple curiosity passes into the love of knowledge as such, and the gratification of the æsthetic sense of the beauty of completeness and accuracy seems more desirable than the easy indolence of ignorance; when the finding out of the causes of things becomes a source of joy, and he is accounted happy who is successful in the search, common knowledge passes into what our forefathers called natural history, whence there is but a step to that which used to be termed natural philosophy, and now passes by the name of physical science.

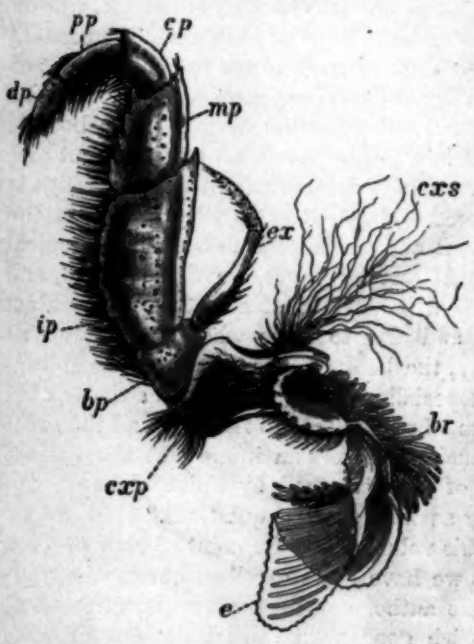

FIG. 1. ASTACUS FLUVIATILIS.—The third or external maxillipede of the left side (×3). *e*, lamina, and *br*, branchial filaments of the podobranchia; *cxp*, coxopodite; *cxs*, coxopoditic seta; *bp*, basipodite; *ex*, exopodite; *ip*, ischiopodite; *mp*, meropodite; *cp*, carpopodite; *pp*, propodite; *dp*, dactylopodite.

"In this final state of knowledge the phenomena of nature are regarded as one continuous series of causes and effects; and the ultimate object of science is to trace out that series, from the term which is nearest to us, to that which is at the farthest limit accessible to our means of investigation.

"The course of nature as it is, as it has been, and as it will be, is the object of scientific inquiry; whatever lies beyond, above, or below this, is outside science. But the philosopher need not despair at the limitation of his field of labor; in relation to the human mind Nature is boundless; and, though nowhere inaccessible, she is everywhere unfathomable."

It is, then, with the object of arriving at a satisfactory conclusion as to the crayfish's place in nature, and to educe from the study of it such conclusions as may tend to throw light on the place in nature of

other living things, that the reader is supposed to enter upon the consideration of the facts which Professor Huxley lays before him.

No pains have been spared in the illustration of the text—the woodcuts (eighty-one in number) reflecting great credit both on the artist for his skill and on the publisher for his enterprise. We have, after a general disquisition on the natural history of the crayfish (by

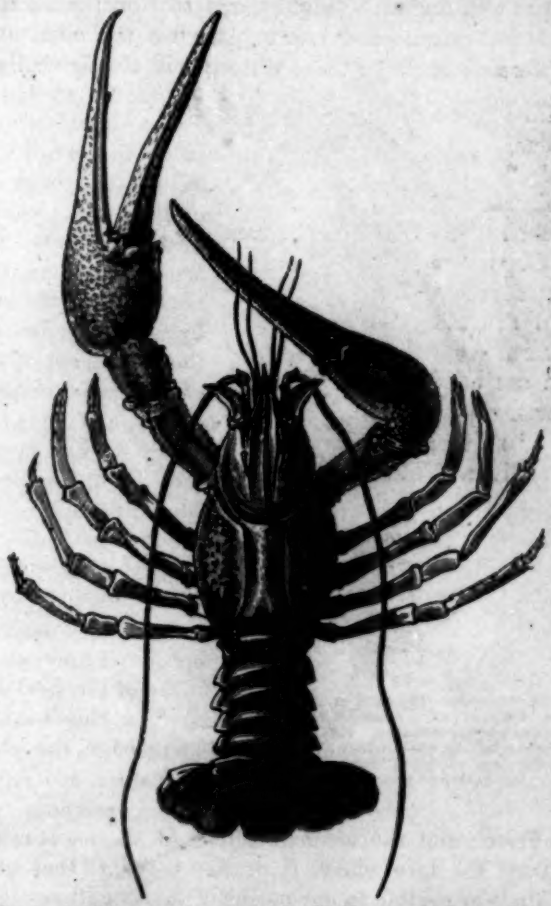

FIG. 2.—ASTACUS LEPTODACTYLUS (after Rathke, one third natural size).

no means the least interesting in the book), two devoted to the consideration of the crayfish as a mechanism—in fact, its physiology. Here a good deal of the anatomy is given and considered from the point of view involved in the question, "What does it do?" Then we have the morphology of the English crayfish—the structure and development of the individual minutely set forth, even each joint of each leg, and each tuft on each gill, and each group of hairs, being described and figured. We are enabled by the courtesy of the pub-

lishers to reproduce one of these highly finished engravings representing the most fully developed of the crayfish's limbs (Fig. 1), and some others which give a fair notion of the excellence of the illustrations of Professor Huxley's book.

To this follows a chapter in which the English crayfish is compared in a variety of points with crayfishes of other lands, such as those of Russia (Fig. 2), of Australia (Fig. 3), and of North America (Fig. 4), with lobsters and prawns, and it is explained how the amount of likeness and difference between these various but closely similar animals

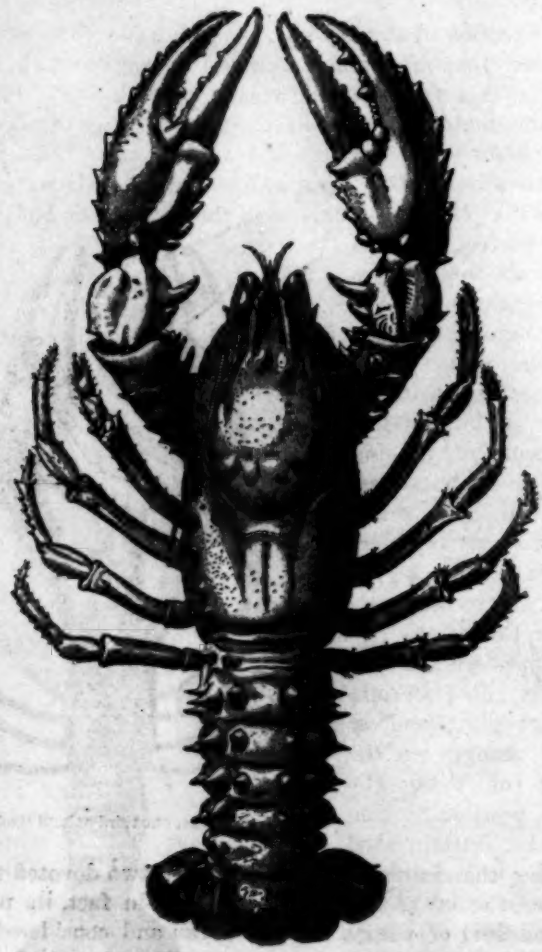

FIG. 3.—AUSTRALIAN CRAYFISH (one third natural size).

may be expressed by the method of classification in groups. Finally, we have a chapter on the geographical distribution of crayfishes, and the facts therein narrated, together with those adduced in the previous

chapter, enable the author to sketch the probable pedigree of crayfishes, that is, to *refer them to their causes*, viz., to the action of such physical agencies as flowing rivers, land and climatic barriers, brought to bear upon successive generations of the offspring of *marine* lobster-like ancestors which had a wide distribution in the earlier Tertiary and later Mesozoic periods, and before taking to fluviatile life had separated into two distinct races characterized by differences of form, the one giving rise to the crayfish of the northern hemisphere (the *Potamobiidæ*), and the other to the crayfishes of the southern hemisphere (the *Parastacidæ*).

The novel portion of this book (novel at least to those who do not study the transactions of learned societies) is that in which Professor Huxley details the very interesting results which he has obtained by a minute examination of the gills attached to the bases of the legs and sides of the body in all crayfish and allied forms. Three series of these gill-plumes may be distinguished according as they are attached to the leg, to the joint-membrane, or to the side of the body (Fig. 5). An ideally perfect crayfish would have all three series complete on each ring of the body in the branchial region (including the region occupied by the three pairs of maxillipedes and the five pairs of walking and nipping legs). But no such realization of the ideal can be found in Astacine nature, any more than in that of the higher Catarrhines. In some crayfish more or less of the leg-gills are suppressed; in others, the body-gills; in others, the joint-gills; and, so ringing the changes on the combination of these elements, it is possible to construct clearly distinguished groups among the crayfishes of many climes, which at first sight seem to differ very little from one another. Further, Professor Huxley shows that crayfishes and lobsters differ from prawns, shrimps, and crabs, in having villous gills instead of laminated gills, in being "trichobranchiate" in place of "phyllobranchiate."

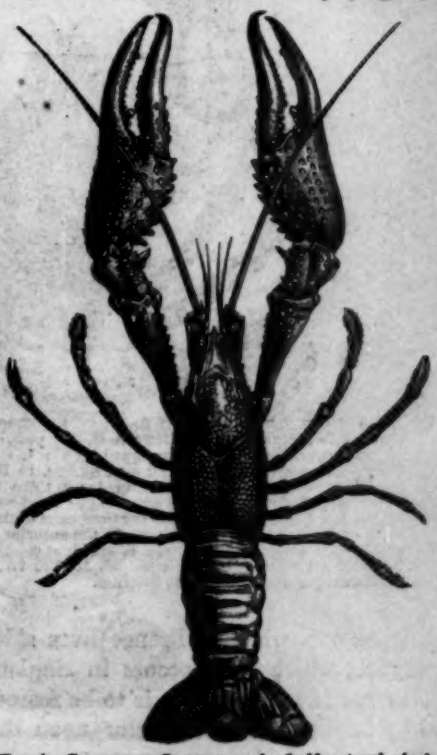

Fig. 4.—Cambarus Clarkii, male (half natural size), after Hagen.

It will probably not be welcome news to some of our readers that the English crayfish is in all probability not entitled to the current title of *Astacus fluviatilis*. This name appears to belong to a larger species, sometimes called *A. nobilis*, hardly distinguishable from the

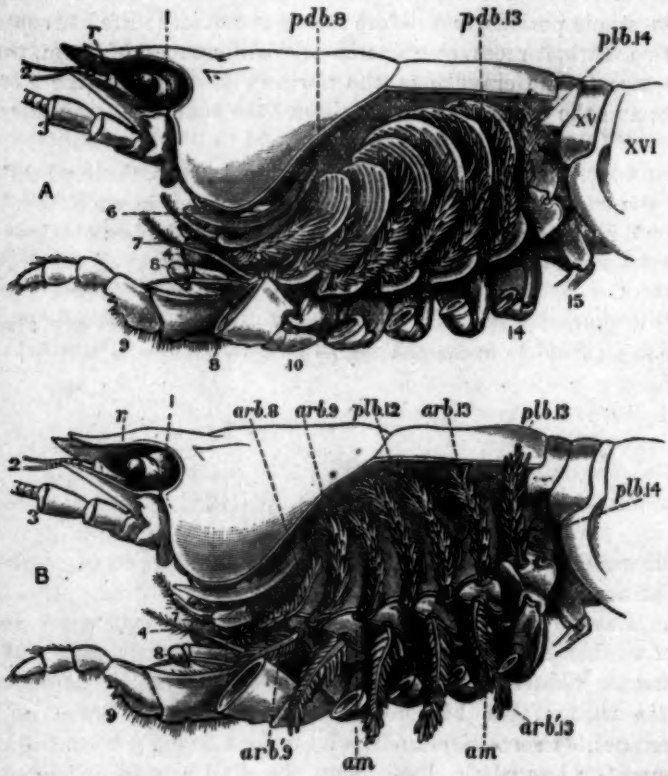

FIG. 5.—ASTACUS FLUVIATILIS. In A, the gills, exposed by the removal of the branchiostegite, are seen in their natural position; in B, the podobranchiæ are removed, and the anterior set of arthrobranchiæ turned downward (× 2): 1, eye-stalk; 2, antennule; 3, antenna; 4, mandible; 6, scaphognathite; 7, first maxillipede, in B the epipodite, to which the line points, is partly removed; 8, second maxillipede; 9, third maxillipede; 10, forceps; 14, fourth ambulatory leg; 15, first abdominal appendage; XV., first, and XVI., second abdominal somite; *arb.* 8, *arb.* 9, *arb.* 13, the posterior arthrobranchiæ of the second and third maxillipedes and of the third ambulatory leg; *arb'.* 9, *arb'.* 13, the anterior arthrobranchiæ of the third maxillipede and of the third ambulatory leg; *pbd.* 8, podobranchiæ of the second maxillipede; *pbd.* 13, that of the third ambulatory leg; *plb.* 12, *plb.* 13, the two rudimentary pleurobranchiæ; *plb.* 14, the functional pleurobranchiæ; *r*, rostrum.

English one, which in France lives side by side with it. The smaller crayfish, which alone occurs in England, is known as *A. torrentium*. This specific title will, it is to be feared, have to be adopted, although it by implication casts a slur upon the river Isis. *A. fluviatilis* has red tips to its legs and a rostrum which differs by a notch or two from that of *A. torrentium*. Further, and this is very curious, *A. torrentium* never has been found to be infested by that very interesting parasite (more interesting even than the crayfish itself), the crab-

leech, Astacobdella, or Branchiobdella, while it is quite abundant on the *A. fluviatilis*, at any rate in some rivers (e. g., the Saale, in North Germany).

A. fluviatilis is largely eaten in France, attaining to the very respectable size of five inches or so in length, while our smaller *A. torrentium* is neglected from this point of view. We can recommend it, however, when boiled in salt and water, as nearly if not quite equaling the prawn. The poisonous properties of the flesh of crayfish might perhaps be considered as justly falling within the scope of the first chapter of Professor Huxley's treatise. As in the case of many mollusca and some true fishes, there appears to be a substance present which acts as an irritant poison upon the human organism, and to its action some persons are more liable than are others, while certain conditions of the crayfish seem to favor the development of a large amount of this poisonous body. A case was recently reported, in a French medical journal, of the poisoning of six persons who partook of a dish of crayfishes—in one case with fatal result.—*Nature.*

LEARNING TO WRITE.

WE wonder sometimes, as we wade through a mass of correspondence, whether it is possible to teach good writing. The doubt may seem absurd, considering that the majority of civilized mankind can write, that every qualified teacher among one or two hundred thousand in Western Europe thinks himself or herself competent to teach the art, and that there must be some hundreds of men in England, or possibly some thousands, who make a living of some sort by practicing this specialty. Everybody, we shall be told, is taught, and some few people write well, and consequently to teach people to write well must be possible. Still, we have this little bit of evidence in favor of hesitation. Nobody ever saw anybody who wrote a thoroughly good hand, and who had been regularly taught to do it. Good handwritings exist, undoubtedly, and are, we should say, rapidly on the increase; but the possessors of the art never admit that they acquired it through teaching, and, in the majority of cases, never were taught. When cross-examined, they always affirm that some man or woman taught them to write, and that then a certain inclination or compulsion of circumstance, or desire to do everything well, or, in frequent instances, a caste feeling, provoked them to teach themselves to write well. They were not taught, except in the most rudimentary sense of the word, and we do not know how they should be. Tutors and governesses have all caught up a system from the professional writing-masters, and the professional writing-masters are all dominated

by two ideas, which are radically false. We always glance over the books they publish, and have read through a new one this week, which we do not intend to advertise in this article, and they are all alike. They all think that "copperplate writing," the special hand of writing-masters and bank-clerks, is good writing, which it is not, being devoid of character, far too regular in form, and from the multiplicity of fine up-strokes not easy to read; and they all believe that certain mechanical motions, if carefully taught, will produce clear writing. They will not, and they do not. There never were two people yet in this world of ours who wrote exactly alike, or who have the same control of their fingers, or who ought, in order to produce good writing, to have held their pens alike, and the effort to make them do it only spoils their natural capabilities. No doubt, those capabilities are often naturally very small. The number of persons who are by nature not deft with their fingers is very large, and so is the number of those who can not fix their attention; while the number of those who can do nothing well which they must do rapidly probably exceeds both. The difficulty of teaching a grown man to write decently is almost inconceivable—he seems never to see what is wanted—and something of that difficulty attaches to a vast proportion of children. Still, all persons not deformed or crippled in the hand, or deficient in eyesight, can be taught to write, and the reason why they are not taught properly must be some inherent defect in the system. We believe it to be the one we have mentioned, the effort to enforce a certain method, instead of trying to secure a certain result. The unhappy child, who is almost always, we admit necessarily, taught too early, is instructed to hold himself or herself in a particular attitude, which is sure to be the wrong one for five sights in ten, the proper attitude depending on the length of the child's vision; to hold the pen at a particular angle, which is also wrong, the fitting angle depending on the character of the pen and holder; and to grasp the pen at a certain distance from the nib, which is arbitrarily fixed, whereas the distance must be governed by the formation and strength of the child's fingers, and would be infinitely better left to his or her own instinct. Above all, there is a perpetual worry about the "resting" of the hand, though the easiest position varies with every child, and though no two men with much writing to do rest the fingers quite alike. The pupil is then taught to make lines in a certain direction, and to copy characters so large that they have no resemblance to writing at all; and to care particularly about up-strokes and down-strokes, and all manner of minutiæ, which, if they are of any value at all, will soon come of themselves. So strong, in spite of centuries of experience, is the belief in this method, that machines for controlling the fingers while writing have repeatedly been invented; and the author of a book before us, a professional, is inclined to tie them up in some fashion with ribbon.

We believe that the whole of this method is a mistake, that there

is no single system of *mécanique* for writing, and that a child belonging to the educated classes would be taught much better and more easily if, after being once enabled to make and recognize written letters, it were let alone, and praised or chidden not for its method, but for the result. Let the boy hold his pen as he likes, and make his strokes as he likes, and write at the pace he likes—hurry, of course, being discouraged—but insist strenuously and persistently that his copy shall be legible, shall be clean, and shall approach the good copy set before him, namely, a well-written letter, not a rubbishy text on a single line, written as nobody but a writing-master ever did or will write till the world's end. He will make a muddle at first, but he will soon make a passable imitation of his copy, and ultimately develop a characteristic and strong hand, which may be bad or good, but will not be either meaningless, undecided, or illegible. This hand will alter, of course, very greatly as he grows older. It may alter at eleven, because it is at that age that the range of the eyes is fixed, and short-sight betrays itself; and it will alter at seventeen, because then the system of taking notes at lecture, which ruins most hands, will have cramped and temporarily spoiled the writing; but the character will form itself again, and will never be deficient in clearness or decision. The idea that it is to be clear will have stamped itself, and confidence will not have been destroyed by worrying little rules about attitude, and angle, and slope, which the very irritation of the pupils ought to convince the teachers are, from some personal peculiarity, inapplicable. The lad will write, as he does anything else that he cares to do, as well as he can, and with a certain efficiency and speed. Almost every letter he gets will give him some assistance, and the master's remonstrance on his illegibility will be attended to, like any other caution given in the curriculum. As it is, he simply thinks that he does not write well, instead of thinking that not to write well is to fall short in a very useful accomplishment and to be *pro tanto* a failure.

We are not quite sure that another process ought not to be gone through, before writing is taught at all. Suppose our boys and girls were taught to read manuscript a little? They are taught to read print, but manuscript is not print, or very like it, and they are left to pick up the power of reading that the best way they can; they never devote half an hour a day for six months to manuscript-reading. If they did, it would be easier to them all their lives, and they would learn to believe in legibility as the greatest, or, at any rate, the most useful, quality that writing can display—an immense improvement, if our experience can be trusted, in the usual youthful ideal on the subject. The business of life, no doubt, soon teaches children to read manuscript; but many of them never read it easily, and retain through life an unconquerable aversion to the work, from the fatigue and vexation which it causes them. We have known men so conscious of this defect that they always have important letters read aloud to them; and others

who would refuse any work, however anxious on other grounds to accept it, if it involved the frequent perusal of long manuscripts in varied handwritings. No doubt the tendency to a broad and coarse but beautifully legible handwriting, which has conquered the upper class and is slowly filtering downward, is diminishing this reluctance, but it would be more rapidly removed if a little trouble were taken to teach children to read handwriting. They hardly see any till they begin to receive correspondence, and are never compelled to read any, and consequently learn to write what they can not read, without intelligence and without pleasure.—*Spectator.*

A CONSIDERATION OF SUICIDE.

By J. H. HOPKINS.

NICHOLAS RIDLEY and Hugh Latimer stood at the stake to be burned for heresy. Fastened to the body of each was a bag of powder, placed there by friends with the intention of bringing the sufferings of the victims to a speedy termination. Latimer died first. The flames, rising rapidly, touched the bag of powder, and the torture for him was at an end. Ridley was not so fortunate. The wood, prepared for his execution, being green and tightly packed, the fire smoldered, and he was long in agony, crying out that he could not burn; until one of the spectators having loosened the fagots and admitted air, the flame swept up to the powder and brought death.

It is certain that the use of powder was not included in the sentence of death. It was permitted, not authorized. Death being sure, the persecutors were magnanimous enough, at the last, to allow it to come quickly. As the Athenian tribunal granted the privilege of hemlock to Socrates; as the English executioners failed to carry out, literally, the horrible sentence of hanging, drawing, and quartering; so the Marian officials did not insist on the extreme rigor of the sentence. But was this hastening of death, in a way unauthorized by law, either murder on the part of the friends of Ridley and Latimer, or suicide on their own part?

Under the old, stern common law, literally construed, the martyrs who used and the friends who furnished the powder were guilty, the former of suicide and the latter of murder. "The law of England," says Blackstone (vol. ii., p. 189), "wisely and religiously considers that no man hath a power to destroy life but by commission from God, the author of it; and, as the suicide is guilty of a double offense, one spiritual, in evading the prerogative of the Almighty, and rushing into his immediate presence uncalled for, the other temporal, against the King, who hath an interest in the preservation of all his subjects,

the law has, therefore, ranked this among the highest crimes, making it a peculiar species of felony, a felony committed on one's self. And this admits of accessories before the fact, as well as other felonies; for if one persuades another to kill himself, and he does so, the adviser is guilty of murder. A *felo-de-se*, therefore, is he that deliberately puts an end to his own existence, or commits any unlawful, malicious act, the consequence of which is his own death." The English laws further provided for the forfeiture of the goods and chattels of a suicide to the King. In the State of New York, a *felo-de-se* does not incur the penalty of forfeiture of property; but "every person deliberately assisting another in the commission of self-murder shall be deemed guilty of manslaughter in the first degree." (2 R. S. 661, § 7.) If a condemned criminal, on the eve of his execution, takes poison, he commits suicide. If, while standing on the scaffold, some one hands him a knife, with which he takes his life, he commits suicide, and the person who furnishes him with the means of death is guilty of manslaughter. If, just before the drop falls, some well-intentioned friend, deeming a speedy death preferable to a slow one, sends a bullet through the heart of the condemned, the friend is guilty of murder.

The relation of suicide to human laws it is not the purpose of this article to consider. Undoubtedly the tacit contract between the government and the individual, while it demands on one side protection to the individual, demands on the other side service to the state; and it rests with neither party to the contract to terminate it at pleasure. Every person, to a certain extent and within proper limitations, places at the disposal of the government under which he lives, his life, liberty, and property. The government becomes the trustee, and, as long as the trust is properly executed, the individual—the *cestui que trust*—has no right to interfere. But we are to consider suicide morally, not legally. The question to be answered is this: Is suicide ever justifiable?

What is suicide? The voluntary termination of one's own life. And this is very different from submission to or acquiescence in involuntary death. A man may long for the approach of death; he may embrace it eagerly when it comes; but this is not the voluntary termination of life. The voluntary termination of life implies some act or failure to act on the part of an individual, which has for its object, in whole or in part, the death of the actor. Suicide, then, is the voluntary termination of one's own life. Is it of any consequence that the involuntary termination is inevitable? Unquestionably not. Death, whether soon or late, is a creditor who never releases his debt; and, if in one case the certainty of death is pleaded in extenuation or justification, the same plea may be offered in every case. Does the proximity of involuntary death furnish any excuse for voluntary death? Certainly not. The hastening of death is the volun-

tary termination of life; and the voluntary termination of life is suicide.

If, then, the fact that death is near and inevitable does not make the voluntary termination of life anything less than suicide, may not the applicability of that word depend upon the motive which prompts such voluntary termination? Here, again, the answer must be in the negative. Keeping in mind the definition, let us suppose that two persons, shipwrecked at sea, find themselves clinging to the same fragment of the wreck, which is not buoyant enough to support both. Either both must drown, or one must push off the other and live by his death, or one must of his own will surrender the entire possession of the floating support to the other and seek death. In the first case death is accidental to both—they retain their grasp on life as long as possible; in the second case death is accidental to the one who is thrust from the support, and his companion is guilty of murder; and in the third case the one who surrenders possession commits suicide. "Greater love hath no man than this, that a man lay down his life for his friend"; but he who displays this great love is literally guilty of suicide. Have not many, whose memory the world honors, been guilty of this so-called crime? What was the act of the legendary Curtius, of the three hundred at Thermopylæ, of Arnold von Winkelried? What is the act of the engineer, who rides to death on his engine to save the lives of the passengers? What is the act of the cashier who, with the promise of death as a penalty for refusal to open the safe, prefers death to dishonor? Are not all these acts suicidal? It can not alter the character of the act that the voluntary termination of life is not brought about by one's own hand. Did not Saul commit suicide, when, at his request, the young Amalekite slew him? If a man, placed on a railroad track by enemies, but released a few moments before the approach of a train, refuses to leave the track and is killed by the train, will it be claimed that he is innocent of suicide? It is evident that, whether a person takes his own life without the intervention of any other agency than the person himself, or places himself voluntarily in a position where death is inevitable, or, being involuntarily placed in a position where death is inevitable, and a way of escape being provided, refuses to take advantage of it—in each and all of these cases the termination of life is voluntary and constitutes suicide.

This interpretation is too stern and hard; and people recognize the fact by refusing to call things by their right names. They do not say that Arnold von Winkelried committed suicide, but that he "sacrificed himself for his country." They do not suggest that John Maynard should be buried at cross-roads with a stake through his body, but assert that he has evinced the most sublime self-abnegation. If John Brown had been promised the freedom of four million slaves, on condition that he should voluntarily submit to death on the gallows, his

acceptance of the condition would not have insured him condemnation, but apotheosis.

It becomes clear, then, that suicide is sometimes not only justifiable but praiseworthy; and men make that justification or praise dependent upon the motive with which life is surrendered. To determine whether the voluntary termination of life is reprehensible or laudable, an answer must first be given to the question whether the act is selfish or unselfish, whether the motive is egoistic or altruistic. If the object is to save others from suffering, the act is justifiable. If the object is merely to save one's self from suffering, the act is unjustifiable.

This distinction between motives seems to be the true one, whether we look at suicide from the purely moral or from the religious and Christian standpoint. Take the Christian apothegm, "Greater love hath no man than this, that a man lay down his life for his friend," or, to put it still more tersely, "The greatest love is shown by altruistic suicide," and discover, if you can, where the line is to be drawn. Does it mean that a man should lay down his life only when, by so doing, he saves the lives of others? Then he may not submit to death, though by so doing he saves millions from slavery—nay, though by so doing he saves a world from slavery. Then he may not abandon life, though by that act he rescues others from eternal agony. Then he must not prefer death to dishonor, but dishonor to death. Then he must hold his own life as more valuable than the welfare of his race. If a promise were made, with the certainty of fulfillment, that should any human being voluntarily submit to death pain would disappear from the world, do you think that he who should give his life in exchange for the happiness of a world would be branded with the mark of crime?

But, if we take the next step and assert that there are other motives, besides the wish to save the lives of others, which will justify a man in voluntarily terminating his own life, where shall we draw the line? If a man may die for the happiness of a world, may he die for the happiness of a million? If he may die for the happiness of a million, may he die for the happiness of a thousand? If he may die for the happiness of a thousand, may he die for the happiness of ten? If he may die for the happiness of ten, may he die for the happiness of one? At what point does the happiness of others accumulate to such an extent as to exceed in value a human life?

Let us suppose a case—one of which experience furnishes numerous examples: A man, through some misfortune, finds himself wrecked and shattered in body; transformed into a living fixture. He can no longer support himself. He becomes a burden for some one to carry. If he is sure that the burden is borne willingly, he may consent to live. But suppose that the shoulders of the bearer ache, and that when death lifts the burden from him he draws a sigh of relief. May not the burden itself provide the way of escape and throw itself from the shoulders of its unwilling bearer to the shoulders of death? Or, take

another illustration. Had Enoch Arden found that the only way in which his return could be kept secret, and his wife and family saved from misery, was by the sacrifice of his life, would he deserve condemnation if he had sought death?

It will be observed that the question has been discussed from an altruistic standpoint. This, of course, excludes Ridley and Latimer. It excludes all those who, threatened with death by disease, and whose life can be saved only at the price of some operation excruciatingly painful, decline to pay the price. It excludes all those who turn to death as a refuge from their own sufferings.

But, viewed in the light of pure altruism, when does suicide become justifiable? Each person must give answer for himself. Every individual is sole judge of the circumstances which justify a surrender of life. It is true that from this opinion orthodoxy dissents. It reasons thus: "Man has been placed upon the earth by God for some good purpose: it is fitting that he remain there until granted leave to return. Let him not enter the presence of his Maker unsummoned." But the same reasoning will serve the most selfish and cowardly egoism. Let the three hundred at Thermopylæ take to their heels, crying out that they will wait until God calls them. Let Arnold von Winkelried leave the field, protesting that he will not usurp the prerogative of the Almighty by assuming control of his own life. Let the men at sea cling to the floating fragment to the last, comforting themselves with the assurance that they have no right to determine for themselves whether their Maker has summoned them. Let the engineer abandon his train with the conviction that his duty to the Author of his being requires him to preserve his life. Certainly orthodoxy does not mean what it says. It cries aloud, "Wait until God calls you"; but adds, *sotto voce*, "Use your own judgment as to what constitutes a call." If it commands men not to take their own lives, it qualifies the command by urging them to lay down their lives for others. In fact, the assertion that men should wait until God summons them is merely putting the case in different language. For who is to decide what constitutes a summons? Evidently the individual himself. But to say that every one must determine for himself what constitutes a summons from God is to say that each person is sole judge of the circumstances which justify a voluntary termination of life.

From the Roman who, devoting himself and the enemy to the infernal gods, rushed to death to bring victory to his companions, to the suicides at the shrine of Juggernaut; from these to the man who "lays down his life for his friend"; from this to the engineer who sacrifices himself for the passengers; from this to the man who dies that thousands may be made happy; from this to the man who refuses to live when his life makes others miserable; from this to the man who turns to death to avoid becoming a burden to his friends—the descent is steady and connected. The last case may claim relationship with the

first; and between all, filling up any imaginable gaps, are numberless other cases which belong to the same family. All these are cases of altruistic suicide. Who shall point out the place where suicide ceases to be honorable and becomes dishonorable? Who shall draw the line and say, "Thus far and no farther"? The later Stoics attempted it, and the distinction which they made was not unlike that of orthodoxy. "If you have no further need for me in prison," says Epictetus, "I will come out; if you want me again, I will return." "For how long?" "Just so long as reason requires that I should continue in this body; when that is over, take it, and fare ye well. Only let us not act inconsiderately, nor from cowardice, nor on slight grounds, since that would be contrary to the will of God, for he hath need of such a world and such beings to live on earth. But if he sounds a retreat, as he did to Socrates, we are to obey him when he sounds it, as our General." Here likewise the decision concerning what constitutes a summons from God rests with the individual. Each person determines for himself the propriety of terminating life.

Condemnation of even egoistic suicide should be indulged in cautiously. Epictetus, indeed, thought that it might sometimes be allowable. "But remember the principal thing," he says, "that the door is open. Do not be more fearful than children; but as they, when the play does not please them, say, 'I will play no longer,' so do you, in the same case, say, 'I will play no longer,' and go; but, if you stay, do not complain." The doctrine was this: A man is directed to play the game of life. God deals the cards. The man may receive hands with which it is impossible for him to win; yet he must play the game to the best of his ability. But suppose he detects his adversaries cheating. He may then throw down the cards and leave the table. It is not always safe to pronounce suicide unjustifiable, even where the motive is a wish to avoid self-suffering. I do not find it easy to regard Ridley and Latimer as criminals instead of martyrs. I do not consider myself competent to declare that he who receives harsh treatment at the inn of life is not warranted in curtailing his visit and returning home.

But, granting that egoistic suicide is blameworthy, who shall pass judgment upon the character of that suicide which has for its motive a desire for the welfare of others? Surely not man. He has no moral balance so absolutely true that he can safely weigh the motives which lead to suicidal self-abnegation, and pronounce some sufficient and others insufficient. Let the decision be left where it belongs—with Omniscience.

VEGETABLE PHOSPHORESCENCE.

By ELLEN PRESCOTT.

THERE is a curious myth which gives to Castor and Pollux, twin sons of Zeus, a divine control over the phosphorescence of air and ocean. Being present by invitation at the marriage of two youths of Amyclæ with the daughters of Leucippus, they became enamored of the brides and with the doubtful courtesy of the period attempted to carry them off. In the ensuing struggle Castor was slain; but Pollux, with a boundless and heroic love that bridged the "abyss 'twixt life and death," besought their father Zeus to restore him, proposing that to meet the ends of justice they should each live only on alternate days. This he granted, and, "kindling stars upon their brows, set them for ever with the immortals."

A religious idea was therefore involved in the superstition of the ancient mariner that the pale phosphoric light, or "St. Elmo's fire," which occasionally appears upon the masts of ships, in an electrical condition of the air, denoted the presence of these divinities as they rode upon the storm-clouds through the heavens. This indicates a recognition of the phenomena of phosphorescence in a remote antiquity; but, in advancing from the philosophy of myths and symbols to an era of empirical knowledge, there was necessarily a period of confusion, when old fancies were replaced by new facts which had not accommodated themselves to the novelty of the position. Even when, through the onward roll of centuries, the wisdom of the ancients had shrunken into grotesque fables, a long period intervened which produced no marked scientific results.

Throughout the seventeenth century inquiry was directed to the phenomena of solar light and the light of incandescent bodies; but, while phosphorescence was everywhere observed, no explanation on scientific principles was attempted, until in 1675 Nicolas Lémery, in a paper on the preparation of solar phosphorus, stated that the light produced was the result of *rapid molecular motion;* thus accepting the doctrine foreshadowed by Huygens and Euler, in opposition to the emission or corpuscular theory of Newton. These prophetic utterances, however, of the present undulatory theory of light were not recognized; it was reserved for later experiment to demonstrate the truth of this intuitive perception.

The "persistence of force" and the "indestructibility of matter" must first be proved, before it could be shown that the phenomena of phosphorescence are due to the same causes as the light evolved by electrical discharge, chemical combination, or mechanical movement. If, as Dr. Young has shown, light be motion or vibration of a luminiferous ether which fills space and permeates all bodies, the conditions

of inexorable law are as fully met in the pale glimmer of luminous plants, the flash of the fire-fly, or the radiance of the glow-worm, as in the light evolved by the heavenly bodies.

The discovery of the luminosity of plants has been attributed to the daughter of Linnæus. In the year 1762, during the months of June and July, she observed radiations of light from a cluster of garden nasturtiums (*Tropœlum majus*), which occurred in the morning or evening twilight. The same effect has been observed in other flowering plants, but principally in those bearing orange-colored bloom, as the corolla of the sunflower, the French marigold, and in the yellow lily. Some species of African marigolds also have manifested this property. Professor Haggern observed the luminous radiations to be most brilliant in the marigold, next in the nasturtium, and, third, in the yellow lily. A careful microscopic examination convinced him that the light did not depend upon the presence of any animal organisms. The rapidity of the flash indicated electrical action, and upon analysis he found that the light proceeded from the petals, the anthers being at an appreciable distance. He supposed that in the process of fecundation the elasticity of the anthers scattered the pollen on the petals and produced electrical disturbance by the impingement of these different substances. In bog or marsh land plants, of the genus *Pandanus*, the rupture of the spathe or shield of the flowers is sometimes accompanied by a loud, cracking noise and a spark of light. In 1857 M. Fries perceived light emitted by a group of poppies (*Papaver orientale*) in the botanical garden at Upsal, to which he called the attention of numerous witnesses.

The phosphorescence discovered by the daughter of Linnæus bore the character of an electrical spark which shot out from the corolla and was discernible at the same hour upon warm evenings when the air was surcharged with electricity. The radiance noticed by M. Fries also indicated a periodicity of movement, occurring always when the air was electrical, between ten and eleven o'clock at night. Not only the blossoms but the leaves of many of the flowering plants have been observed to emit a phosphoric light under favorable conditions of the air—even the milky juice of several vegetables becomes luminous in the dark; this was particularly noticed by M. Martins in a species of the phosphorescent spurge (*Euphorbia*).

The *giving out of heat* in the blossoming of plants was discovered by Lamarck more than a century ago in the European arum, which in opening "grows hot as if about to burn." It was afterward observed by De Saussure, and by the later appliance of the thermo-multiplico the heat *generated* in any cluster of blossoms is made appreciable. The development of this force is most remarkable in tropical plants, where a large number of flowers are crowded together under a covering hood of spathe. The temperature increases periodically, growing greater in the afternoon and appearing like a "paroxysm of fever"

which passes off with the decline of day—the greatest intensity always occurring *during the shedding of the pollen.* Any great increase of temperature is necessarily prevented by the equalizing effect of evaporation from the expanded surfaces of the leaves, and the water which pervades all the substances. It is only during a period of unusual energy, as in blossoming, that the heat becomes apparent.

The light and heat set free by combustion we recognize as merely the expression of chemical change and a giving back to original elements the forces that were stored up by vegetative activity in the coal-beds of the past or in the woody fibers of later growth. In the mysterious circle of Nature's means and mechanism, light, heat, and chemical combination are alternately cause and effect—not, it is true, in the abstract sense of cause, but, being mutually convertible or corelative, maintain necessarily reciprocal action. Now, the fact that they are thus reactive and interchangeable as *modes of motion* offers a very simple explanation of the giving out of light by plants at a moment when the *surplus amount* of these garnered forces is thrown off during the vital processes of reproduction.

That increased chemical activity exists at the period of flowering is shown by the exhalation of an unusual amount of carbonic acid, and this increased action supplies the additional heat for the elaboration of the reproductive agents, whose preparation seems to be the highest expression of energy in vegetable organization. Some doubt exists as to the proximate cause of the manifestation of light by flowerless or cryptogamic plants, in which are embraced the mosses, fungi, etc. A study of the conditions under which it is presented will, I think, enable us to refer it directly to similar chemical action.

These plants were ingeniously named by Linnæus because the concealed organs of reproduction offer great diversity in structural relations—a diversity so great that they can not even be presented under one common type; we must, therefore, look for modifications in the expression of force directed by these different forms. The root-hairs which form in the germination of one of the liverworts (*Hepaticæ*) have been observed to be luminous in the dim light of caverns. It gathers principally upon schists, and derives its name (*Schistostega Osmundaceæ*) from a miniature resemblance to the royal fern *Osmunda.* This plant, like the true cavern-mosses, is emerald-green, and develops into root, stem, and leaf. The dainty fern-like leaves or fronds are of the very simplest organization, and a slender, thread-like stem rises from the apex, bearing upon its summit a valvular case or capsule which contains the reproductive cells or sporules. The root-hairs which give out the light appear like the tangled meshes of a spider's web; and, as the same effect has been noticed in these tenuous structures, some naturalists have attributed the appearance to reflected light. But analogy in the condition of this and other light-emitting plants leads to the conclusion that it is self-luminous.

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The phosphorescence of fungi has been observed in various portions of the world. Rumphius first noticed its appearance in Amboyna in a species of corticium to which the name *Telephora cærulum* was given. Under this specific name are grouped many minute forms of fungi, only the mycelium of which were known to Linnæus and Agardh, the discovery of other organs forming the complete plant being of more recent date.

Among mushrooms four of the genus *Agaricus* are luminous, and have been examined with special reference to this effect by Delille, Fabre, and Tulasne: The red or orange-colored species (*Agaricus olearius*), inhabiting the adjacent soil or roots of olive-trees in Central Europe; the fire-mushroom, or *Agaricus igneus*, which Rumphius discovered in Amboyna; the *Agaricus noctilucus*, found at Manila by Gandichaud; and *Agaricus Gardineri* of the Brazilian provinces, growing upon the dead leaves of the Pindoba-palm. The red mushroom of the olive-trees is wonderfully beautiful. The gills curve out from the pedicle and expand under the pileus into a trumpet- or bell-like form of almost vermilion hue, which changes at night into a pale-blue light, gleaming, where they are massed together, like blue bells of fire.

M. de Candolle erroneously supposed that the phosphorescence of the *Agaricus* of the olive occurred only at the time of its decomposition. M. Fries, with equal error, attributed the effect to the presence of a secondary parasite; Tulasne, however, denies that the seat of light is in the mold, and states that he has observed the phosphorescence of the plant itself. He agrees with Delille in regarding the appearance as limited to the period of growth, and refers to it as a "manifestation of vegetation." M. Delille supposed the radiance to be intermittent, while M. Fabre observed that exposure to the sunlight appeared to have no influence whatever upon the phenomena, and that the light was exhibited at any time under cover of darkness. Dr. Phipson, in reviewing M. Fabre, remarks that this seems, however, to indicate that the light of the sun has in reality an influence upon the emission of light during the daytime, and that the phenomenon is probably a case of phosphorescence after insolation. But as we know the *Agaricus* belongs to that class of colored parasites which are destitute of green foliage, and consequently of proper digestive organs of their own, and draw support from the elaborated products of the foster-plant, the phosphorescence may be accounted for as the result of chemical action under conditions where the influence of solar light is not required to produce a higher combination.

Tulasne recognized that the light was not confined exclusively to the reproductive surfaces, and proved by dissection that the whole mass offered scintillations. This is probably due to a sympathetic or highly vitalized condition of the whole plant during the process of fecundation, as is indicated by the juice of the phosphorescent euphor-

bia. The light, however, is usually emitted by the organs of reproduction; this is particularly the case in young fungi, while, in the older ones, after the luminosity has disappeared from the gills, the surface of the stipe becomes radiant.

The mycelium of the root-shaped fungi (rhizomorpha) penetrates through the decaying organic matter of wood and coal deposits, exhibiting a clear pale light. This has been particularly observed in the mines near Dresden, Hesse, and occasionally in England. These flowerless, gleaming plants impart a weird beauty to the caverns of granitic rock in Bohemia, illuminating them with a pale mimicry of moonlight.

The most remarkable instances of cryptogamic phosphorescence have been noted by Mr. Gardner in Brazil, by Dr. Cuthbert-Collingwood in Borneo, by Mr. Hugh Low and James Drummond in Australia, and by Mr. Worthington-Smith in the Cardiff coal-mines. Rev. J. M. Berkeley cites an instance in England, where a dazzling radiance was observed upon a spruce or larch log, which continued for several days—a byssoid mycelium, yielding an unusually pungent odor, being recognized. The common potato also, in decomposing, generates a peculiarly luminous parasite; and, at one time, an alarm of fire was sounded in the streets of Strasburg from the light produced by a decaying mass stored in a cellar. An instance has recently come to my notice, where a brilliant light was thrown off by pieces of cantaloupe, after a few hours' exposure to the air.

Wherever, then, we encounter decomposing vegetable matter, we observe some form of fungi living upon and appropriating the changed substances of a former condition to the generation of a new life. What, therefore, seems to us a loss or waste, is merely change—change of form, change of condition. The absorbing roots of these parasites grow into the tissues of the host in the most intimate manner, deriving from a disorganization of the substances the elements necessary to their own being.

Vergil describes the blighting mildew on the grain as "an unbidden crew of graceless guests that choke the fields"; and De Barry writes that there is a frequent unbidden guest in every household, who lays under contribution its stores of sweets. The mold or mildew which gathers on the surface of preserves is a plant of exquisite beauty when viewed with low magnifying power and by reflected light, for what appears to the naked eye only a soft, white, woolly crust, becomes a glittering forest of graceful stems and branches, standing like fine-spun silver upon the dark background of the supporting surface. This substratum is in reality a mycelium, or system of fine interlacing, thread-like roots, which form the vegetative part of the plant, and are woven into a soft, black or brown velvety substance, through which run russet, scaly hairs. The branches rise to about the fiftieth of an inch, and bear the fruit and seed-cells. Higher microscopic power

reveals the spores which are the analogues of seed, although they possess neither their vestments nor organs, but are simple membranous sacs (full of liquid), which germinate at some indefinite point of their convex surface into a new plant like that which produced them.

A comparison of the condition of flowering plants and of the mosses and fungi, during a phosphorescent display, will lead us to attribute the appearance to similar action of vital forces, if we for a moment review the processes by which these forces are accumulated. In the growth of plants heat acts as a dynamic agent, which the germ of the plant directs and uses. The first action of growth consists in the conversion of the starch of the seed into a soluble form, and in chemically combining the starch, sugar, oil, and albumen by fermentation into the protoplasmic matter which supplies the material for the tissues of the plant. The development of this protoplasm into organized tissue is due to the inherent power of the germ, and marks the second stage of progress. The only action of light is employed in producing higher chemical combination; heat acts as the constructive power.

The process of growth does not absorb all the elaborated materials provided, and an additional amount of heat or force is generated by the decomposition or a "retrograde transformation" of these compounds. A much greater proportion, however, of the organized substances is stored up within the structure of the plant as a "reservoir of reserved material," to meet the exhaustive process of flowering and the maturing of fruit and seed. That these processes are sustained at the expense of an extra amount of force, and by the decomposition of their own products, is evident from the unusual production of carbonic acid. The combination of carbon, oxygen, and hydrogen, in the building up of plants, is here reversed, and by a retrograde process heat is set free, which we have seen is necessary for the elaboration of reproductive agents.

This appears to be precisely the same action which takes place in the reproduction of fungoid plants and mosses. A corresponding condition is shown by the rapid exhalation of carbonic acid; indeed, Dr. Carpenter asserts that a decomposition of a portion of the absorbed material is the only conceivable source of the large quantity they are constantly giving out, and ascribes the very rapid growth of these plants to a "retrograde metamorphosis." The substances which enter into the new growth are already prepared by the foster-plant, and we find the parasite incapable of forming any new combination through the agency of light. This necessarily awakens a doubt of any action resulting from insolation or reflection in the cases of the liverworts or mushrooms which have been referred to.

The expression of light in flowering plants seems to be through the medium of electricity, while in cryptogams it resembles the steady glow of slow combustion. High microscopic power may, however, reveal, as in some cases of animal phosphorescence, the sparkle and flash

of rapid and minute scintillations. Inquiry in this direction, I think, has never been made; nor is an analysis necessary for our present purpose. For, if we regard the light either as the result of slow combustion, or catch the vivid flash of the electric spark in this reproduction (itself the product of decay), we are met by the same inexorable permanent law, that there is not a leaf that rots by the roadside, nor a spear of pale club-moss, that is not in itself a reservoir of recreative power throwing back its faint, pulsing light or its equivalent of heat into that quickening flood which the great heart of Nature sends down through the illimitable and unknown.

CROLL'S "CLIMATE AND TIME."*

By W. J. McGEE.

THE recent publication in "The Popular Science Monthly" of a paper on "The Age of Ice," and its apparently favorable reception and republication elsewhere, prompt the writer to submit the following incomplete notice of a work in which the field barely entered by the author of that paper is most thoroughly and exhaustively examined.

In addition to a convenient abstract of the line of argument pursued, and a statement of some fundamental principles of geology, it is pointed out in an introductory chapter that the earlier theories framed to account for climatal variations during the geological æons are utterly inadequate; that the earth could not pass through hotter or colder portions of space without seriously deranging the mechanism of the solar system; that a diminution of heat from this or any other cause could never inaugurate a glacial epoch; that considerable changes in the obliquity of the ecliptic have never occurred, and could not have caused glacial periods if they had; and, finally, here as well as in a more recently published paper,† which may be considered as supplementary to this chapter, that material changes in the position of the terrestrial axis can never have taken place: in short, he shows, by bringing together the independent results arrived at by eminent geologists, physicists, and mathematicians, that the various cataclysmic theories of geological climate are alike untenable. Telluric causes being thus shown to be incompetent, no alternative remains but to

* Climate and Time in their Geological Relations: A Theory of Secular Changes of the Earth's Climate. By James Croll, LL. D., F. R. S., etc., of Her Majesty's Geological Survey of Scotland. American edition, 12mo, pp. xvi.–577, with Plates. New York: D. Appleton & Co., 1875.

† "Geological Magazine," September, 1878.

seek for the cause of secular climatal variations in the earth's astronomical relations. In the same chapter, but more fully in the Appendix, Dr. Croll goes on to show that the variable length of the seasons consequent upon the ellipticity of the terrestrial orbit had begun to attract attention before the close of the last century; and that, as early as 1830, Sir Charles Lyell had expressed the idea that the long winters and short summers of the southern hemisphere might have some influence in lowering the temperature of that portion of the globe.* Sir John Herschel and others, however, soon after demonstrated that the light and heat received by any portion of the earth's surface during any year is practically invariable, whatever the eccentricity of the terrestrial orbit; the greater proportionate length of winter in the hemisphere whose winters occur in aphelion being exactly counterbalanced by the greater proximity of the sun in summer. This is, indeed, a legitimate deduction from Kepler's second law, and was long ago demonstrated by D'Alembert. The hypothesis, therefore, fell into disrepute. Over fifteen years ago, however, the author of the work under consideration began to point out, in a series of papers (chiefly in the "London and Edinburgh Philosophical Magazine"), the substance of which is reproduced in "Climate and Time," that while the variable length of the seasons resulting from this cause could never produce a glacial epoch *directly*, yet the same cause might, especially when intensified by a high degree of eccentricity, bring into operation a chain of physical agencies which could not fail to very materially affect the climate of the globe.

As a further introduction to that portion of the work devoted to the elucidation and application of the above-named astronomical and physical principles, and as an illustration of the efficiency of one of the secondary agencies on the operation of which the theory is based, the heat-conveying power of ocean-currents is discussed at length in the second and third chapters. The importance of these currents is shown to be immense. Thus, according to Professor Dove's "Temperature Tables," the temperature of the British Isles, and of western Europe generally, is 12° Fahr. above the normal—or, more properly, the mean—for that latitude, while the temperature of corresponding portions of eastern North America is nearly as much below the normal. Dr. Croll attributes this difference to the effect of the Gulf Stream in warming western Europe, and of the cold counter-current in chilling our American coasts. The same subject is recurred to frequently throughout the volume, notably in Chapters XI. and XII., in the latter of which Mr. Findlay's objections are answered by calculating from his own data that the heat liberated from the Gulf Stream in the North Atlantic is equal to more than one half of that received directly from the sun in the same latitude. An analogous condition of things exists on the shores of the North Pacific, which are similarly

* "Principles," first edition, 1830, vol. i., p. 110.

affected by the Kuro Siwo; though there the effect is less distinctly marked, owing to the more unfavorable conformation of the coast. So effective are ocean-currents in distributing the heat of tropical and the cold of polar regions, that our author concludes that the globe would not be habitable for existing orders of beings were their influence to cease.

The heat-conveying power of aërial currents is also discussed; but it seems possible that Dr. Croll has under-estimated their capacity, many times increased as it is by the aqueous vapor with which they are laden. Space will not, however, permit the discussion of this interesting point.

The combined effect of aërial and aqueous currents is estimated to reduce the difference in temperature between equator and poles from 218° to 80°. This astonishing result may be substantially verified by a simpler and probably more accurate method than that employed by Dr. Croll. Meech shows* that the relative solar intensity at the equator, at the poles, and over the whole earth, varies in the ratio of 81·50, 33·83, and 66·73, respectively; and Dove, many years ago, determined the mean annual temperature of the earth to be approximately 58°. Now, the solar energy elevates the temperature of the earth from that of stellar space, or −239° (as determined by Herschel and Pouillet), to +58°. 297° is, therefore, the mean elevation of the earth's temperature by solar action. Eliminating the distributing power of aërial and aqueous currents, and assuming the present mean relation between absorption and radiation to remain constant, it is quite probable that the temperature of the various parts of the earth's surface would vary directly as the solar intensity. A simple proportion, then, shows us that while the equator would be raised 363°, or to +124° of absolute temperature, the poles would be elevated only 150°, or to −88°; making a difference of 212° between equator and poles. If, as is extremely probable, the temperature of stellar space is really below −239°, this difference would be still greater. Moreover, it can be shown that any decrease in temperature tends to increase the radiating capacity of the earth by rendering the surrounding atmosphere diathermous. Hence the poles would sink lower in temperature, proportionally, than the equator.

Six chapters (VI.–XI.) are devoted to the "gravitation theory" of oceanic circulation, with the object of completely refuting it. Two reasons for the very full discussion of this branch of the subject are given: 1. Because the gravitation theory "lies at the root of a great deal of the confusion and misconception which have prevailed in regard to the whole subject of ocean-currents"; and, 2. Because, "if the theory is correct, it militates strongly against the physical theory of secular changes of climate advanced in this volume." The advo-

* "Relative Intensity of the Sun's Light and Heat," "Smithsonian Contributions," vol. ix.

cates of this theory are separated into two arbitrary classes: 1. Those who consider the difference in density between equatorial and polar waters to be due to difference in saltness; and, 2. Those who attribute the difference in density to difference in temperature. Lieutenant Maury's theory, stated in his "Physical Geography of the Sea," is rejected because that eminent meteorologist recognized both of the above-named causes of difference in density, while they are very nearly equal and quite antagonistic, and because the actual differences in specific gravity due to these causes are mathematically demonstrable to be incompetent to produce so powerful currents; being, in fact, as Dr. Croll pointedly insists, only one seventh of that necessary to produce the slightest motion. Dr. Carpenter's theory, based chiefly on differences of density due to differences in temperature, is discussed at still greater length than Lieutenant Maury's, and is rejected on the grounds—1. Of being counteracted by differences in saltness (in which view Dr. Croll has the support of Sir Wyville Thomson); and, 2. Of resting on assumed causes utterly inadequate either (*a*) to produce existing currents, or (*b*) to convey northward so great an amount of heat as that shown to be given out by the Gulf Stream; the apparently paradoxical conclusion, that the Gulf Stream actually conveys an absolutely greater quantity of heat to high latitudes than the whole Atlantic could convey, being explained by the proposition that the Gulf Stream obtains the greater portion of its heat in the southern hemisphere, while according to Dr. Carpenter's hypothesis the circulation should be independent in each hemisphere.

In Chapter XIII. the "wind theory" of oceanic circulation is enunciated and elaborated, and in the succeeding chapter its relations to climatal variations are discussed. It is first pointed out that the various ocean-currents are not due to the trade-winds alone, as was until recently supposed by advocates of the wind theory, but to the general impulse of the prevailing winds of the globe, viewed as a single grand system, and acting, not upon several separate and independent oceans, but upon a single grand oceanic system, the various parts of which are most intimately related. The correspondence between the supposed cause and the observed effect seems to be all that could be desired. "All the principal currents of the globe are in fact moving in the exact direction in which they ought to move, assuming the winds to be the sole impelling cause. In short, so perfect is the agreement between the two systems, that, given the system of winds and the conformation of sea and land, and . . . the system of oceanic circulation might be determined *a priori*. Or, given the system of the ocean-currents, together with the conformation of sea and land; and the direction of the prevailing winds could also be determined *a priori*. Or, thirdly, given the system of winds and the system of currents, and the conformation of sea and land might be roughly determined." Return currents are formed through the tendency of

the ocean to maintain its level, and naturally select the path of least resistance. Hence they are usually undercurrents.

The general agreement between the systems of winds and of oceanic circulation is shown on a chart. It may be mentioned that the direction of the winds, as laid down on this chart, does not precisely correspond with the direction determined by the late Professor Coffin, and indicated on the charts in his cyclopean work, "The Winds of the Globe," recently published by the Smithsonian Institution; and it is quite probable that more exhaustive observations will show that there are inaccuracies of as great magnitude in the representation of oceanic currents. It should be borne in mind, however, that any minor discrepancies between the two systems do not militate against the theory, unless it can be shown that they are not such as would be produced by the conformation of the coasts; for the wind system, as a cause of oceanic circulation, is modified by this important and frequently antagonistic factor.

In seeking for demonstrative evidence of the correctness of the wind theory, Dr. Croll seems to fall into an error which he has repeatedly had occasion to point out in others. Thus, in discussing one of Dr. Carpenter's sections, he shows, from Professor Muncke's coefficients of the density of sea-water, at various temperatures, that the surface of the Atlantic is, at north latitude 23° 10′, two feet six inches, and at north latitude 37° 54′, fully three feet six inches higher than at the equator, on account of the greater thickness at these points of the upper layer of warm water. It is urged that "gravitation never could have caused the ocean to assume this form," and hence that "gravitation can no more cause the surface-water of the Atlantic to flow toward the Arctic regions than it can compel the waters of the Gulf of Mexico up the Mississippi into the Missouri." Now, by Dr. Croll's own showing, it is gravity alone that causes the surface of the Atlantic to assume that form—that is, if that form is actually assumed; a fact not determined by measurements. It is merely calculated from the data given to what height above the level at the equator the waters of the North Atlantic would have to be raised in order to maintain a condition of static equilibrium; it is not shown that the waters are so elevated, but only that they would have to be in order that the influence of gravitation, in producing oceanic currents, should be eliminated. How the warm water, on which this supposed configuration depends, was conveyed thither, is a dynamical and not a statical problem.

Moreover, two important elements in the problem of oceanic circulation are disregarded by Dr. Croll: 1. The water borne from equatorial to polar regions by aërial currents, in the form of aqueous vapor, must exercise a powerful influence not only on the earth's temperature but also upon marine currents; for, as shown by Lieutenant Maury, it is sufficient to permanently render the Arctic seas much less saline than those of tropical regions. Sir Wyville Thomson strongly insisted upon

the importance of this agency in his presidential address before the geographical section of the British Association, at its Dublin meeting, in which he even went so far as to maintain that one part of the general oceanic circulation takes place through the atmosphere; though in thus considering the aërial circulation to be telluric, or universal over the whole surface of the earth, instead of hemispheric, or comparatively independent on opposite sides of the equator, this distinguished explorer seems to assume to be true that which is most emphatically contradicted, not only by the almost innumerable observations collated by Professor Coffin in the great work already referred to, but by those of all other observers. It is true, though, that, as the transportation of the vapor is accomplished by aërial currents, these currents *indirectly* cause those marine currents formed by the precipitation of vapor. 2. The earth's axial rotation, which is one of the two great causes of aërial circulation, must exercise considerable effect on the marine currents, though of course its operation is more seriously interfered with by the inequalities of the terrestrial surface in the case of the earth's discontinuous liquid envelope, than in the universal gaseous one. Still, if, as suggested by Guilleman, this force is adequate to influence the course of rivers flowing to the north or south, it will vitiate any theory which neglects it. Moreover, the actual effect of the earth's axial rotation would be very likely to elude observation, as the currents so produced would necessarily correspond approximately with the principal aërial currents of the globe; and hence the combined effect of the two causes would be likely to be attributed to the most obvious one. The influence of axial rotation on the oceanic circulation may be determined mathematically, however, and indeed such an investigation has already been entered upon by Mr. Ferrel; but his results are not generally known.

While both branches of the gravitation theory are summarily dealt with, analogy with the second prime cause of aërial circulation (i. e., difference in density, owing to differences in temperature and humidity) would indicate that any difference in density, whether due to difference in temperature or in saltness, would be sure to play a minor part in the phenomenon of oceanic circulation, at least in some cases. Therefore, of the five distinct agencies which probably coöperate in disturbing the equilibrium of the ocean, Dr. Croll recognizes but one; and, singularly, in view of his usual method, he nowhere endeavors to prove mathematically, or in any other conclusive manner, that the impulse of the winds is adequate to produce the effects attributed to it. The wind theory can not, therefore, be said to be demonstrated. Nevertheless, the agreement between the winds and the marine currents is so striking that geographers and navigators are generally disposed to adopt that theory. The late distinguished geographer of Gotha, Dr. Petermann, was one of the most prominent advocates of the theory.

With Dr. Croll's connection with this subject a new era may be said to have been inaugurated. Previously it had been deemed sufficient to point out certain agencies which *seemed* to be adequate to produce the observed effect, without making any effort to show mathematically that they *were* adequate; but this physicist contended from the first that cause and effect should be determined in *absolute measure*, just as in the other branches of physical science. His failure to observe this excellent rule in one case is to be attributed to the same paucity of trustworthy observations which is the occasion of the obscurity enveloping the whole subject.

In Chapter IV. the physical agencies leading to changes of climate are discussed, and an explanation of the present low temperature of the southern hemisphere is offered in Chapter V. As has already been intimated, that hemisphere, which has its winters in aphelion, has a longer winter and a shorter summer than the mean. Now, it is perfectly obvious that this variation in the length of the seasons increases with any increase in the eccentricity of the terrestrial orbit, and similarly diminishes with any diminution of eccentricity; for the eccentricity of the planetary orbits may vary within pretty wide limits, which have been determined by La Grange, Leverrier, and, more recently as well as more satisfactorily, by Mr. J. N. Stockwell, of Cleveland. The present eccentricity (0·0168) is such that there is a difference of about eight days in the length of summer and winter in either hemisphere, when the solstices coincide with the apsides; and, the winter solstice of the southern hemisphere being now not far from aphelion, that hemisphere has the long winter and short summer. It is admitted, however (even too readily, it would seem), that the present degree of eccentricity is too insignificant to exercise much influence on the climate of the globe; but 210,000 years ago, when, according to Dr. Croll's elaborate computations, the eccentricity was 0·0575, the excess of winter over summer, due to this cause, amounted to 26·7 days; and 850,000 years ago, the eccentricity then being 0·0747, it amounted to 34·7 days; and it is argued that so great a difference in the relative length of the seasons would indirectly, through the intervention of a number of physical agencies, materially affect the earth's climate. These agencies are shown to be such as would be brought into operation by an increase in the length of winter, even if its severity was not increased; and they are mainly dependent on the increased proportion of moisture precipitated as snow instead of rain. Of course, this snow would remain until melted by approaching summer, just as it does in every region where much snow falls.

"There are three separate ways whereby accumulated masses of snow and ice tend to lower the summer temperature": 1. By means of direct radiation [and by direct contact]; 2. By direct reflection back into space of the solar rays; and, 3. By chilling the air and condensing the vapor into thick fogs which intercept the solar rays. This

third influence had better not be insisted upon, however, as it is counteracted by—1. The immense amount of latent heat liberated in the condensation of the vapor; and, 2. The interception by these fogs of the heat radiated from the earth. A substitute may be offered for it, viz., by rendering the atmosphere diathermous, and therefore incapable of absorbing the solar rays or of intercepting the radiation and reflection from the earth. In consequence of the operation of these agencies, the air in snow-covered regions seldom rises above the freezing-point, and the solar heat is conveyed away into space and utterly lost to the earth; for, if a portion of it is absorbed by the snow and ice during the hours of sunshine, it is not rendered sensible, owing to the high latent and specific heat of these forms of water, and is radiated away, unchecked by any "protecting blanket of vapor" (which Professor Tyndall shows to be so efficacious in protecting the earth from radiation, but which can not exist above snow-covered regions), during the succeeding hours of darkness.

This *waste* of solar energy, in turn, still further curtails the already short summer, and permits the same causes to operate with increased efficiency during the succeeding season. Moreover, the reaction of each effect upon its cause is such as to strengthen the cause, and the interaction of all the agencies is such as to increase the efficiency of each. Each winter would thus add to the snow which had remained unmelted during the intervening summer, until the accumulation of snow was checked by the absence of vapor for condensation and precipitation; for, as pointed out by Tyndall, the presence of large quantities of vapor is the first essential for the formation of extensive glaciers.

It has been objected to the theory, that this picture has been overdrawn—that no such slight cause could so seriously disturb the equilibrium of the seasons; it has even been shown mathematically that the heat of a few days in summer would melt the total accumulation of the previous winter. The answer to these objections is, that in such calculation the operation of the agencies just described was disregarded, and hence that its results are unreliable; that, though the solar intensity is greater over polar regions in summer than in the tropics, as shown by Meech, it is not sufficient to melt the annual accumulation of ice, else this ice never could have accumulated to so vast an extent as to annually send forth thousands of colossal bergs to be melted in temperate seas; that not only in the Alps, but even in the almost tropical Himalayas, where the sun shines with undiminished intensity throughout the year, the direct effect of the solar energy is so far below the accumulation of congealed vapor that the ice is only prevented from piling up indefinitely by that property which enables it to flow down to lower levels where the conditions described do not exist; that even in the northern portions of our own country the slight annual film of snow retards the coming of summer by weeks if not months;

that while the reception and dissipation of heat by any portion of the earth's surface are equal, the physical properties of ice are such that ice-covered regions lose their heat *immediately* without being sensibly increased in temperature. The effect on temperature of accumulations of ice and snow must, therefore, be enormous. "Were it not for the ice," strikingly remarks Dr. Croll, "the summers of Greenland . . . would be as warm as those of England; but, instead of this, the Greenland summers are colder than our winters. Cover India with an ice-sheet, and its summers would be colder than those of England." Even on our own coasts the grounding of a single berg appreciably lowers the temperature and greatly increases the danger of frosts.

On the hemisphere whose *summers* occurred in aphelion during the period of high eccentricity, an exactly opposite tendency would be manifested: the snow and ice would gradually melt and perhaps entirely disappear, and vegetation might flourish even under the pole. That hemisphere would then enjoy an *interglacial* period. These periods occupy an important place in the theory under examination.

Dr. Croll then proceeds to show how the accumulation of ice in polar regions would affect the general oceanic circulation: "Owing to the difference between the temperature of the equator and the poles there is a constant flow of air from the poles to the equator. It is to this that the trade-winds owe their existence. Now, as the strength of these winds, as a general rule, will depend on the difference of temperature that may exist between the equator and higher latitudes, it follows that the trades on the cold hemisphere will be stronger than those on the warm. . . . Suppose, now, the northern hemisphere to be the cold one. The northeast trade-winds of this hemisphere will far exceed in strength the southeast trade-winds of the southern hemisphere. The *median-line* between the trades will consequently lie to a very considerable distance to the south of the equator. . . . Let us now consider how this would affect the Gulf Stream. The South American Continent is shaped somewhat in the form of a triangle, with one of its angular corners, called Cape St. Roque, pointing eastward. The equatorial current of the Atlantic impinges against this corner, but, as the greater portion of the current lies a little to the north of the corner, it flows westward into the Gulf of Mexico and forms the Gulf Stream. . . . Now, it is perfectly obvious that the shifting of the equatorial current of the Atlantic only a few degrees to the south of its present position—a thing which would certainly take place under the conditions we have been detailing—would turn the entire current" to the south of Cape St. Roque, and thence along the Brazilian shores and into the Southern Ocean, and "the Gulf Stream would consequently be stopped."

Now, it is quite manifest that if the wind theory of oceanic circulation is incorrect—and, as already shown, its correctness has not been

demonstrated—no such deflection of the Atlantic current would be likely to occur. This possibility is fairly confronted by Dr. Croll when he admits that the gravitation theory "militates strongly" against his theory of secular changes of climate. But there is another self-evident proposition which seems to have escaped his attention. Assuming that the results detailed above follow in the order laid down when the eccentricity is at a high value, it is perfectly manifest that *the deflection of the Gulf-Stream feeder is an effect of glaciation*, and, if a cause at all, only a secondary one. Hence, if the purely physical agencies *alone* are capable of causing glaciation, Dr. Croll's theory of secular changes in climate will stand, whether or not the wind theory of oceanic circulation is correct; but, if they are *not* capable of producing a glacial period *alone*, the theory will fall, even if the wind theory of oceanic circulation be correct. This can not be too strongly emphasized. Yet, not only in "Climate and Time," but in his other publications on the subject, Dr. Croll dwells upon the deflection of ocean-currents as the principal telluric element in his theory!

The only positive evidence adduced to prove that the Gulf Stream was deflected during the glacial period is the fact, pointed out by Mr. Crosskey, that there is more difference between the glacial and recent shells of Scotland than between the glacial and recent shells of Canada. But this only proves that the present temperature of that part of Canada is lower than that of Scotland; for the temperature of the waters at the edge of the ice-sheet must have been approximately the same, whatever the latitude to which it extended. This evidence is, therefore, utterly valueless. Furthermore, we have pretty reliable positive evidence that the Gulf Stream was not stopped during the glacial epoch, in the more northerly limits of continental glaciation in those parts of Europe so greatly affected by the Gulf Stream to-day, any more than in the United States, where its influence is comparatively unfelt. Moreover, Professor Dana has shown in his "Journal" that the distribution of ice during the glacial period coincided in a general way with the present distribution of rainfall in the same latitudes. Now, the greater part of the moisture of the United States, especially of the great Mississippi Basin, is derived from the Gulf of Mexico; and the stoppage of the South Atlantic feeder of the Gulf Stream would cool the waters of the Gulf so considerably as to materially diminish our vapor-supply, and at the same time the distribution would be altered. Similarly, the stoppage of that current during the glacial period would have so altered the distribution that its relation to the present precipitation would not be recognizable, even if it did not so completely cut off the vapor-supply as to prevent glaciation. The mass of evidence is therefore against the hypothesis of the shifting of this important marine current during the glacial period; and, as this would, as Dr. Croll points out, be likely to be the first out of all of the ocean-currents to be deflected, it may reasonably be doubted whether

any were seriously affected by the cause specified. It must be admitted, however, that the physical agencies which have already been described seem competent to inaugurate a glacial epoch during any period of high eccentricity of the terrestrial orbit, without any assistance from the meteorological influences. These periods, recurring at long and irregular intervals, must have alternately refrigerated and revivified the circumpolar regions again and again during the immeasurable ages whose lapse is so dimly recorded in the rocky strata. The theory is, therefore, in the highest accord with the modern uniformitarian doctrine which rejects all hypothetical explanations of phenomena which are not in harmony with the present course of nature.

The present low temperature of the southern hemisphere as compared with the northern is explained by the assertion that the warm waters of the southern hemisphere are borne into the northern, while the cold waters of the northern hemisphere are conveyed into the southern. The argument supporting this conclusion is that of a radical advocate of the wind theory, and is as strongly opposed to the first principles of the physical theory of climate as the most conservative critic could wish. Space will not permit the discussion of this chapter.

Chapter XVIII. contains a *résumé* of the evidence of former glacial eras which had been collected up to the time of the preparation of the volume. There had already been placed on record more or less decisive evidence of former glaciers, not only in the Quaternary but in the Miocene, the Eocene, the Cretaceous, the Oölitic, the Permian, the Carboniferous, the Old Red Sandstone, the Silurian, and even the Cambrian. In some of these cases, notably in the formations of the Permian age, the evidence is so voluminous, so distinct, and from such widely separated localities, that it seems impossible not to conclude that our Pleistocene ice age was but the homologue of long antecedent secular winters. The reasons for the paucity of evidence regarding these early glacial eras are summarized in the preceding chapter.

A statement of the method of computing the eccentricity of the terrestrial orbit, elaborate tables (laboriously computed by the author, with the exception of about a dozen periods) showing the eccentricity for 3,000,000 years in the past and 1,000,000 years in the future, and conclusions as to the probable date of the glacial epoch, constitute Chapter XIX. It has since been pointed out, by an undoubted authority in such matters (Professor Newcomb), that Leverrier's formulæ, which were employed in making the computations embraced in the tables, are defective, and hence that the figures given are not rigidly correct; but for the present these minor inaccuracies may be disregarded. The dates given may, therefore, be assumed to be correct, though they are undoubtedly only approximations.

It has already been stated that periods of high eccentricity occurred 210,000 and 850,000 years ago, respectively. Sir Charles Lyell, the founder of the uniformitarian school of geology, was inclined to

believe that it was the first of these periods that produced the glacial epoch. Guided by the rate and amount of post-glacial erosion, however, Dr. Croll concludes that it was the more recent period which corresponded with the Quaternary glacial epoch; but he suggests that the earlier period may have coincided with the Miocene glacier. He thinks that the glacial period of the Quaternary lasted from shortly before the last great maximum until about 80,000 years ago (when the eccentricity was 0·0398, corresponding to a difference of twenty-two days in the length of the seasons), or for about 160,000 years—including, of course, the alternating interglacial periods.

Aside from the strong inherent evidence of the approximate correctness of this determination of the date of the glacial epoch (any uncertainty being due to the imperfection of Leverrier's formulæ), there is an abundance of independent testimony leading to substantially the same conclusion. Many eminent geologists have calculated the duration of post-glacial time from various data—generally the rate and amount of erosion or deposition in stated localities—with results usually ranging from 100,000 to 300,000 years. The mean of several of the most reliable is a trifle less than 200,000 years. Now, while each of these results, when viewed singly, may properly be regarded, in the words of Sir John Lubbock, "not as a proof, but as a measure of antiquity," they may, when viewed collectively, justly be considered reliable within wide limits, and to *prove* that no less a period than 40,000 or 50,000 years can have elapsed since the retreat of the ice-sheet from temperate latitudes; and the time has now come when he who endeavors to fix a later date for that event, without showing why these estimates should be rejected, need not be astonished if his efforts only bring him into contempt. So great is the weight of this independent testimony, indeed, as to warrant the suggestion that the glacial epoch of the Quaternary did not extend down to the period of high eccentricity 80,000 years ago, as Dr. Croll intimates, but closed 160,000 or 170,000 years ago. This last maximum might, then, be represented by the Reindeer epoch of Europe, and possibly (if it may be permitted in this strongly reactionary age to suggest the bare possibility that the pioneers in the field of American archæology, Atwater, Morton, Squier, and their compeers, did not err most egregiously in their estimates of the antiquity of the earlier works of our prehistoric races) by the migration into Mexico and Central America of the mound-builders of the Mississippi Valley—a migration which might thus furnish a parallel with that southerly migration of the Pliocene mammalian fauna at the inception of the glacial period, to which the Indian geologists attribute the richness and variety of the Siwalik and related fossil fauna of the Orient. It might further be urged that, if the duration of the ice age were so great as Dr. Croll suggests, we would be likely to find more unequivocal evidence of the fact in structural variations in those species which survived the cataclysm.

Interglacial periods are treated of at considerable length in Chapters XV. and XVI.; and it is justly held that any theory which does not explain the occurrence of the plant-beds of the drift, as well as its bowlder clays, is unworthy of acceptance. The fossiliferous strata of the marine formations found in Arctic regions, as well as the whole series of fossiliferous deposits found in the drift, are referred to these brief periods of unusually mild climate; but this seems almost too radical. If the general series of marine deposits in the Arctic regions were as nearly unfossiliferous as are the sedimentary strata of tropical India, such an hypothesis would be a little more likely to find acceptance among geologists. The fact developed by Meech, that the polar regions ought to have a warmer summer than the equator, if the solar intensity is a fair criterion, would indicate that these regions should have only a temperate climate if the ice were removed and the summer's heat stored up in the earth; and so slight an additional quantity of heat would accomplish this in a few years that, in view of the known variability of the solar emission and of the terrestrial absorption, it seems quite unnecessary to attach so much importance to the interglacial periods in their relations to Arctic formations. That coal is an interglacial formation, as is suggested in Chapter XXVI., seems still less probable, chiefly because these periods are too short to admit of so great an accumulation of vegetable matter as is stored up in each coal-seam.

It is not improbable, indeed, especially if the marine currents were not seriously affected by the polar snows, that the greater part of each of these periods would be required to melt the ice which had accumulated during the preceding glacial period. It seems very doubtful, too, even if the melting of the ice took place with the greatest conceivable rapidity, whether terrestrial animals or plants would spread over the barren wastes of crude glacial *débris* so rapidly as to people so wide a zone in the brief period assigned. Some of the intercalated fossiliferous beds of the drift, too, are very rich in numbers as well as species of both animals and plants—the latter sometimes forming extensive deposits of lignite—which must have required an immense time for their development. It seems scarcely possible that these terrestrial deposits can be interglacial, in the sense in which Dr. Croll employs the term, though the aqueous deposits, containing fossil shells of marine and estuarine mollusks, may justly be so considered; for such animals would be likely to keep close to the margin of the ice-cap as it retreated. To explain the two principal divisions of the drift, which have been recognized over immense areas on both sides of the Atlantic, it seems equally reasonable to refer the uppermost to the last period of high eccentricity, and the lower to that which Sir Charles Lyell supposed to coincide with the glacial epoch; in fact, in support of this collocation, we have the striking coincidence that the ice extended some degrees farthest during the period of greatest eccentricity.

Besides, such a collocation affords a sufficient period for the development of the rich and characteristic fauna and flora of the forest-bed—a widespread fossiliferous and carbonaceous deposit that must represent a lapse of time of geological importance. The belief that any glacier would necessarily remove all the *débris* formed by an antecedent one—a belief which has done much to prevent the acceptance of theories of successive glaciation—is best shown to be fallacious by the unequivocal evidence that the ice of the last glacial epoch did pass over older deposits of unconsolidated materials without removing them. Some such evidence is cited by Dr. Croll in the last-named chapters.

Among the interesting cognate subjects taken up in the remaining eleven chapters of the work are—methods of measuring the rate of subaërial denudation, and of determining the mean thickness of the rocks of the globe; the age and origin of the sun (which is an able effort to reconcile the existing disagreement between the geologist and the astronomer and physicist as to the age of the earth); the physical cause of continental submergence and emergence during the glacial period; the influence of the obliquity of the ecliptic on terrestrial climate; some glacial phenomena of Scotland and England; and the physical cause of glacier-motion. Appendices and an index are added.

It has been the aim in the foregoing pages to convey a general idea of the nature and scope of the work under review, and at the same time to indicate those points which do not seem to be sustained; and, as is natural in view of this double object, justice has not been done to the work as a whole. "Climate and Time" represents years of study and an almost incredible amount of conscientious labor by perhaps the most competent living man to deal with this obscure subject, which occupies a position intermediate between geology, physics, and astronomy, and requires a thorough knowledge of all of these branches of science for its adequate comprehension. As a geologist, Dr. Croll occupies an important and responsible position; and, as an astronomer and physicist, his reputation in scientific circles is even more enviable. Owing to the confusion in which he found the subject, to the absence of reliable data, and perhaps to a rather radical disposition, he seems to have fallen into a few errors; but, with some reservations, his ingenious theory has been received with much favor, and has been pretty widely adopted, especially on the other side of the Atlantic. Here, it is comparatively unknown, and, in too many cases, lack of acquaintance with the principles on which it is based has led to its being unfavorably regarded; but even those who reject the theory would do well to familiarize themselves with its details before they undertake to investigate the subject anew.

A LIVING HONEYCOMB.

MUCH as has been written about the marvels of instinct, there are still discoveries of great interest to be made in this prolific field. Particularly in the domain of those insect Yankees, the ants, with their wonderful ingenuity and human-like manners and customs, there is room for extended observations.

Some lately discovered facts in relation to them are so curious and interesting that it may be advisable to give them greater publicity than they have yet obtained. Some of these facts have long been known to the world of science, but not to the public. Others are new discoveries. As a whole they form one of the most surprising chapters in the history of animal life and contrivance.

Varied as are the social habits of the ants, it is generally considered that social bees surpass them in one particular, namely, their mode of storing supplies of winter food, the storehouses of ant-food having no contrivance similar in ingenuity to the honeycomb, with its rich supply of the sweets of life.

But the truth is that certain tribes of ants are well aware of the value of nature's sweetmeats as articles of food, and have developed a mode of storing up their winter honey still more curious than that practiced by the bees. They possess, in fact, what may be called living honeycombs; perambulatory cells filled with distilled sweetness. We refer to the honey-bearing ants of New Mexico, concerning which some very interesting facts have been brought to light during the past summer.

The Rev. Dr. McCook, of Philadelphia, a noted observer of ants and ant-life, has been interviewing these honey-bearers, and his results differ so widely from the ordinary facts of insect instinct that they can not but prove of general interest. These ants had been previously known only in New Mexico, but he discovered them in Colorado, inhabiting the locality known as the "Garden of the Gods," their nests being excavated in the stony crests of low ridges which run through this mountain-girt paradise.

The ridges are composed of a friable sandstone, into which our minute masons mine deeply, digging galleries which sometimes run for several feet into the rock. The nest, outwardly, is some ten inches in diameter by from two to three and a half inches in height, composed of sand and bits of stone carried from within, some of which seem large enough to defy a regiment of ants to move them.

Inside the nests successive chambers are excavated, connected by galleries, the floors of the chambers being comparatively smooth, while the ceilings are left in a rough state. But this roughness is no evidence of carelessness in the builder. It has, on the contrary, an im-

portant object: this is to furnish foothold for the clinging feet of certain extraordinary-looking creatures, which form the living honey-combs of which we have spoken.

Fancy an animal with the head and thorax of a small ant, but with all the posterior portion of the body converted into a round sac, of the size of a large pea, and of a rich translucent amber hue—it being, in fact, distended into a reservoir of honey. This honey-bag is immense when compared with the size of the ant, the unchanged parts of which might pass for a black pin's head attached to the side of a marrowfat pea. These odd-looking creatures cling to the roof of the chamber with their feet, the distended honey-bag hanging downward like an amber globe. On seeing them we instinctively imagine that their leg-muscles must be developed in a fashion to put to shame those of human athletes, since it is no light weight which they are thus forced to continuously support.

In each chamber of the nest about thirty honey-bearers are found, making some three hundred to the complete nest. Besides these there are hundreds or thousands of others, workers and soldiers, lords and queens, to whom the honey-bearers serve as storehouses of winter food.

Dr. McCook succeeded in bringing some of these home with him alive, providing them with nest-building materials, and with sugar for nutriment. He has one very interesting nest in a glass bottle, with its interior chamber well displayed. The roof of this is covered with depending globules of honey, so large as almost to conceal the minute clinging insect of which they really form a part.

But the marvelous feature of the case yet remains to be described. Not only is the abdomen of the ant converted into a receptacle for honey, but the whole internal economy of the body is transformed for this purpose. All the organs of the abdomen have quite disappeared: viscera, nerves, veins, arteries, have alike vanished; and there remains only a thin, transparent skin, which is capable of great distention. It is thus in reality a honey-cell, and much stranger than that of the bee, the waxen walls of the latter being replaced in this case by the tissues of a living animal. The creature can afford to dispense with the abdominal organs, since its life-duties are so metamorphosed that it has henceforth to act only as an animated sweetmeat.

Dr. McCook's observations enabled him to discover that the working ants, returning from their out-door foraging, with their bodies distended with the honey they have somewhere harvested, enter the chambers of the nest and eject this sweet fluid from their own mouths into the mouths of the honey-bearers, whose bodies become greatly distended with the delicious food. In other cases he perceived hungry ants seeking for a meal from the food thus generously stored up. The honey-bearer seemed to slightly contract the muscles of the abdominal skin, forcing from its mouth minute globules of honey: these

clung to the hairs of the under lip, and were eagerly lapped up by the hungry ants waiting to be fed. It is probable, however, that these supplies are principally intended as winter stores for the workers, for the feeding of the larvæ, and for the dinner-table of the queen, who is, as usual, too proud or too dignified to do her own foraging.

The working ants take great care of their helpless honey-bearers. When one, through some convulsion of nature—occasioned perhaps by the tap of a gigantic human finger—looses its hold and drops to the floor of its chamber, it is at once picked up by a worker, and carried back to its old foothold on the roof of the apartment. How this minute creature can drag up a perpendicular wall a mass twenty times its own size and weight is only less surprising than it would be to see an adroit climber of the human race ascending the face of a precipice and pulling after him a ton weight.

With regard to the source of the honey, these ants are not known to feast on flowers, like bees and some of our home ants, nor could any evidence be found of the presence of the *Aphis*, or ant-cow, which many of our ants milk for its honey.

The honey-gatherer is difficult to observe. It is a nocturnal ant, keeping out of sight of the sun during the day, and only venturing forth at nightfall in search of food. Dr. McCook observed them, in the summer twilight, marching outward from the nest in long columns, and pursuing night after night the same paths. He watched them for a considerable time before he succeeded in finding the goal of these nightly expeditions. At length, discovering some ants on the twigs of a species of scrub-oak, which grew abundantly at the foot of the ridge, he observed that they showed a marked preference for certain small oak-galls which were ranged along the sides of the twigs.

The next thing to be done was to examine these galls. We are accustomed to associate galls with the idea of bitterness only, yet they proved to be the true honey-yielders. On the round, green masses minute drops of a sweet juice were found: this the ants eagerly licked up, passing from gall to gall until fully laden, or returning to the original gall at a later hour when fresh sweetness had exuded from it.

The gall-nut, it is well known, is an excrescence upon the leaves of a species of oak; it is produced by the puncture of a small hymenopterous insect for the purpose of depositing its eggs. A minute grub lies in the center of the soft mass which composes the gall. Whether the sweet juice came from this grub, or from the sap of the tree, was not readily to be discovered, though it was most likely an exudation of the sap.

All night the busy gatherers of sweets were occupied in collecting honey from the galls. Toward morning they were seen in great numbers returning to the nest, their bodies swollen with the night's harvest of honey, which, as we have said, is given to the living honey-

combs within, being forced from the bodies of the workers and into the mouths of the honey-bearers, until, by the time the season is over, they present a remarkable distention.

This is about all that is known at present concerning the habits of these strange ants. They very likely have other sources of honey at other seasons; but the most interesting fact is the surprising mode of storage of this sweet food.

In New Mexico the inhabitants put these ants to a very peculiar use, supplementing their dinners with a plateful of honey-ants for dessert. The overladen insects wait in enforced patience while the preceding courses of the dinner are being eaten. The mode of partaking of this strange dessert is to pick up an ant, nip the honey-bag with the teeth, forcing its sweet contents into the mouth, while the remainder is thrown away. We are told that this is not so disagreeable a habit as it might at first sight seem, the skin surrounding the honey being reduced to a thin, transparent membrane, with nothing necessarily unpleasant in its character. Nevertheless, most of us will prefer to continue indebted to the bee for our supply of honey, leaving the ants to enjoy the fruits of their own labors.—*Journal of Science.*

SIZE OF BRAIN AND SIZE OF BODY.

By H. W. B.

IT may be stated generally that the larger the animal the smaller is the proportionate size of the brain. As an example of this we may take the case of two of the largest animals now living, viz., the whale and the African elephant. The whale possesses one of the largest brains that is found in any animal, but, if we compare the size of its brain to that of any of our domestic animals, such as the dog, we find that it has a very small brain in proportion to the size of its body. The same is the case with the brain of the elephant, which is certainly the largest brain of any land animal, but which, compared to the size of the body, is very small. Another set of animals in which the brain is comparatively small is the reptiles. This group includes a number of animals which are not included in the popular sense of the word, such as the crocodiles, the turtles and lizards, as well as the snakes. In these the brain is small comparatively to the size of the body, as it is also in the amphibia. The small size of the brain in these two classes of vertebrates is peculiar, as it runs through all the various groups, although most marked in the larger members of each one. The birds also follow the rule that the largest of them have smaller brains compared to their bodies than the smaller ones have. A good example of this may be seen in the case of the ostrich, which has the largest

body of any member of the group, but a much smaller brain in proportion to its body than many of the smaller birds. As a class, however, the birds have large brains in proportion to their body, when compared to the other vertebrates, and so present a contrast to the reptiles, in which, as already stated, the brain is small throughout the whole group. In the next class of vertebrates—the Monotremata—the brain is large in proportion to their body, but it must be taken into account that this group contains very few large animals, being composed almost entirely of small ones. The size of the brain in the echidna, and the ornithorhynchus, both belonging to this group, is especially large in proportion to the small bodies which the animals possess. This is more remarkable when we consider the low position they occupy in the vertebrate series. In this manner we might go on through the whole series of vertebrates, showing how the larger animals have relatively smaller brains, and also the reverse, that the smaller animals have larger brains for their size.

We must now consider, however, the relative size of the brain in animals about the same size, as it is only in that way that we can gain information on the subject. Owing to the difficulties which attend the investigation of this subject, comparatively little is accurately known about it. It may be stated generally that the brain of domestic animals is larger than that of wild animals of a corresponding size of body. As an example of this we may take the case of the dog and the wolf. If the brains of those animals are compared, it will be found (if the animals compared are of the same size) that the brain of the dog is the larger. Again, if we compare the brains of a dog, a badger, and a musk-deer about the same size, we find that the brain of the dog is the largest, those of the other two animals being about the same size. It will be observed that, in classifying the size of an animal, we do not go by the height the animal stands, because many animals whose bodies are about the same size differ in height only on account of their legs being longer. In making comparisons, therefore, we compare animals whose bulk is the same, irrespective of the actual height they may stand from the ground. Among the wild animals of a similar size, we also find considerable difference between the comparative size of the brain and that of the body. As an example of this, we may take the case of the lion and tiger. The brain of the lion is much larger than that of the tiger; however, that might be expected from the lion being a larger animal than the tiger; but the brain is much larger in proportion than the difference of size of the two animals would account for: therefore the brain of the lion is larger, in proportion to the size of his body, than that of the tiger is in proportion to his body.

But we must now compare the size of the brains of domestic animals of the same size. Although the horse stands higher than the ox, yet both those animals may be classed together for the comparisons of their brain. We find that the brain of the horse is very much larger

than that of the ox. The camel also may be included in this class, as being about the same size. Although many camels are larger, still the bulk of the body is not very much greater than that of the horse and ox. Its brain is very similar in size to that of the ox, but smaller than the horse's brain. The brain of the sheep is a good deal larger than that of the goat, although their bodies are similar in size. The sheep and the pig are also animals which we might classify if we do not take extreme sizes, but compare animals similar in age or bulk. We find that the pig's brain is larger than the sheep's, and corresponds in size very nearly to that of the dog. In the cat the size of the brain, in proportion to the body, is much larger than that of the domestic rabbit, although the size of the two animals is very much the same.

In these examples given we have not taken into consideration the order to which the animal belongs in the vertebrate series, but only compared similar sized animals, and in all cases we have compared the brains of adult animals. This is a very important point, as it is found that in all animals, including man himself, the size of the brain, in proportion to the size of the body, is much greater in young animals than it is in the adult. In some animals the head is found to grow enormously in size as the animal reaches adult age, but the brain does not increase to the same extent. There is generally some reason to be found for this in those animals where it takes place. For example, in the elephant the head of the young animal is by no means out of proportion to the size of its brain; but if we bisect the head of an adult animal we find that the brain only occupies a small cavity, and the rest of the skull is composed of plates of bone with air-cells between them. In the young elephant we find none of those plates and air-cells between the outer and inner layers of cranium, but simply the two layers of bone close to one another; but we will also find that at this stage the young elephant has no large tusks to carry, and its trunk is light, so that its head is comparatively light. The case is, however, quite different in the adult, when there are two large tusks and a large trunk to carry. In order to support this great weight he requires strong muscles. The great increase in the size of his head, therefore, is to afford a requisite extent of surface for the attachment of the muscles. In order to get this, combined with lightness, the skull is composed of those plates and air-spaces mentioned.

A very interesting question, but one which it is very difficult to answer, is whether the intelligence of the animal corresponds to the size of its brain. It is very difficult to make comparisons in many animals, as one animal shows his intelligence in one way, and another in another way. However, going over some of the animals whose brains we have compared, we may take as an example the horse and the ox. The horse has the larger brain, and he has undoubtedly the greater amount of intelligence. We find that horses can be trained to a great extent, as may be seen daily in a circus, but the ox has never been so

trained. Again, a dog is the most intelligent animal there is, and he has a large brain in comparison to the size of his body. On the other hand, however, if we examine some of the Monotremata, we find, as already stated, that the brain is very large in proportion to the size of the body; but the animals of this group would by no means be taken as a standard of animal intelligence. It appears very probable, therefore, that in young animals and in the lower classes of the vertebrates the size of the brain has comparatively little to do with the intelligence the animal possesses, but that in the higher vertebrates there is some relation between the amount of intelligence and the quantity of brain-matter. The question may be asked, Why is it that the elephant, since it has the largest brain of any land animal, is not the most intelligent animal there is—more intelligent even than man, if the intelligence of an animal depends on the amount of its brain-matter? The answer to this question is easy. This animal being so large requires proportionally larger nerves and larger nerve-centers, to supply the muscles and sensory organs of his body, in the same manner that a larger magneto-electric machine is required when twenty electric lights have to be supplied by it than when it has to supply only ten. The elephant has, in reality, a smaller quantity of brain material available for his intelligence than the dog, because the dog has a much smaller body, and requires smaller nerves. Moreover, the intelligence, it has been proved, is situated in the upper part of the brain, or cerebrum, as it is called. Now, the dog's cerebrum is very much larger, in proportion to the size of his body, than that of the elephant, after allowing for the general law that larger animals have smaller brains in proportion to their body than smaller ones have. The number of smooth and tortuous eminences called convolutions, separated by grooves, which cover the whole surface of the upper brain or cerebrum has also been proved to have something to do with the amount of intellect of the animal. The brains of those animals which possess superior intellect are generally more highly convoluted and more deeply divided by the grooves than those of lower intellect. This may be very well seen by comparing the brains of the horse and the ox. It will at once be seen on looking at the brains of those two animals that the horse's brain is the more convoluted and altogether the more complex structure of the two. The same thing may be seen in the brain of the pig on comparing it with that of the sheep. As an example of brains where the convolutions are few in number and the grooves between them very shallow, we may take those of the echidna and ornithorhynchus, already mentioned as being very large in proportion to their bodies, while they themselves are of a low type. The intellect of those animals evidently does not correspond to the size of their brain. The probability is, therefore, that their brain-matter is of a low type and consequently a larger quantity of it is required. Besides these examples cited there are many more that could be brought forward. It may be stated gen-

erally, then, that the intelligence of an animal depends principally upon the size of the brain in proportion to the size of its body, the size of the cerebrum, and also upon the number of convolutions and the complexity of its structure, although there are many exceptions to this rule which we are still unable to account for.

Another interesting point in connection with this subject is the great increase in the size of the brain that has taken place within the last few hundreds of years, without a corresponding increase in the size of the body in all animals. This very interesting fact we learn from fossil zoölogy. The brain of animals at the present day is much more developed than it was in former times. This may be owing to the struggle for existence which there is, the animals which are weaker in body and intellect gradually being extinguished by the stronger, so that only the latter remain and are allowed to propagate the species. We know that exercise and training strengthen the brain and increase its weight in man, so the probability is the same thing takes place among the lower animals. There is every likelihood, therefore, that the brain will still go on developing as time advances.—*Land and Water.*

THE TEXTILE PLANTS OF THE WORLD.

DR. HERMANN GROTHE, of Berlin, has published a work on the textile fibers furnished by the world of plants, embodying the fruits of studies pursued among the yarn and cloth materials of all nations at the great Industrial Exhibitions that have been held at the European capitals and in Philadelphia. The subject is one of much interest, in an economical sense, and in the relation it bears to the development of early civilization. Men's first steps in civilization may be traced almost directly in their efforts to clothe themselves; and their first essays in skilled labor are made in the adaptation of the materials which nature has furnished them to use for dress. On the banks of the White Nile are tribes who content themselves with simple aprons of leaves, or less; and Sir Samuel Baker noticed that a great advance in general civilization had taken place when, after having spent several months among peoples of that grade, he came into Unyoro, where the people wore garments fashioned out of the bark of a fig-tree, which they had to prepare by soaking and beating with a mallet. Thrift seemed to follow naturally upon the acquisition of the taste for clothing, for the fig-trees have to be cultivated to secure a sufficient supply. Accordingly we are told, when a man takes a wife, he plants a certain number of the trees in his garden, as a provision for the wants of the family he has in prospect. A grade above the naked races are the Papuans of New Guinea, with their loin-girdles of grass or palm-

leaves; and above these are the Maoris of New Zealand, with their cloaks of the leaves of an agave-like plant laid upon each other like scales. The South-Sea Islanders have in the paper-mulberry a plant which serves the same purpose to them as the fig-tree to the people of Unyoro, from the bark of which they prepare the *tapa* by soaking and beating. They illustrate another development of industry in the adornment of their clothes, for which they have invented an endless number of designs, many of them of considerable merit. This stage of civilization is also often marked by a corresponding development of the potter's art, and of skill in ornamenting vessels. From the method of using the whole stuff of the bark to the art of separating its fibers and spinning and weaving them into a cloth is a great step. The processes of spinning and weaving are as varied as are the people who carry them on, and are largely determined by the nature of the material to which they have to be applied.

Dr. David August Rosenthal, in his "Synopsis Plantarum Diaphorecarum" (1862, Erlangen), counts, among twelve hundred useful plants, three hundred and sixty species which are fit for weaving, spinning, basket-work, cordage, etc.—species which are distributed over the whole earth, and of which nearly every country has some which may be cultivated with profit.

Dr. Grothe divides the textile fibers into seed, bark, stalk, and leaf fibers. Those of the first class, the seed-fibers, are derived principally from the species of cotton, concerning all of which we have as yet no comprehensive treatise. Several other families of very diversified character afford seed-fibers, for which no method of application has yet been found which would permit them to be compared with the cotton. The plants affording valuable bark, or bark-fibers, are far more numerous. Dr. Grothe enumerates thirty-one families, of which seventeen are dicotyledonous, twelve monocotyledonous, one is a gymnosperm, and one is a fern. Among the dicotyledonous plants are species of flax, linden, birch, mallows, sterculiaceæ (or silk-cottons), thymelaceæ (Daphne, leatherwood), asclepiads, apocynaceæ (dogbanes), nettle-plants, leguminous plants, mimosæ, spurge, willow, myrtle, bread-fruit, compositæ, and byttneriaceæ. The cultivation of the flax-plant has extended to the antipodes. Near to it in importance are the plants of the linden family, which afford numerous species suitable for basket-work and for woven fabrics. At their head stands the corchorus (not the so-called *Corchorus japonicus*, or Japan rose of the gardens, which is a spiræa), of which the species olitorius and capsularis are the plants of the jute-fiber, and have recently attained an extraordinary value. The cultivation of these plants, which was formerly carried on only in India and the Sunda Islands, has spread to the Southern United States, Brazil, Australia, New Caledonia, Mauritius, Guiana, and Algeria, and the production of the fiber, according to Dr. Grothe, already equals half that of cotton. Other

lindens worthy of notice for their textile value are the aubletia petoumo, of Guiana, and several species of triumphetta. The mallow family, to which the cotton-plant belongs, affords a great many textile plants of the genera abutilon, hibiscus, sida, lavatera, malva, althea, abelmoschus, etc.

Passing by the hemp, the value of which is generally recognized, we come to the nettle family, to some of the members of which an increasing degree of attention has been directed at all the great exhibitions since 1851. The common stinging-nettle has been used in Europe for a long time in making the nettle-cloth; the fibers of other species have recently been made into a handsome hair for dolls' heads, and might be put to more practical uses. Some twenty-four species of Urtica, Böhmeria, Puya, and Wood-nettle are enumerated as more or less valuable, besides the *Nerandia melastomæfolia*, which is used in the Sandwich Islands. Of the whole number, *Urtica nivea* stands in the highest estimation as the plant from which the well-known China-grass or grass-cloth is made. It is cultivated extensively in the provinces of China south of the Yang-tse-kiang, the export from which had reached about thirty-five hundred tons in 1872, and is now estimated at about eleven thousand tons. The fiber is used in Japan for the finest threads and cloths, and an active manufacture has been carried on since 1660, hemp and jute having been used before that time. The Puya and the Neilgherry nettle (*Urtica heterophylla*) are also highly valued for their fibers. Another family, allied to the nettle, the Antidesmeæ, is represented in the Malabar flax (*Antidesma alexiterium*), which is employed for spinning and in ropes. Among the monocotyledonous families that afford useful fibers are the lilies, irises, amaryllises, bromeliaceæ (or pineapple family), palms, pandanus (or screw-pine), rushes, grasses, reeds, and sedges. Of the plants of these orders most famous for their fibers are several species of agave and fourcroya, which afford the strong pito hemp, several species of anana (bromeliaceæ), and the bananas, one of which, the *Musa textilis* of the Philippine Islands, produces the Manila hemp, one of the handsomest and most valuable of all the fibers.

SKETCH OF DR. CHARLES F. CHANDLER.

PROMINENT among the men who have won large distinction by varied and valuable labors in the field of science in this country, stands the name of the subject of the present notice. His career has been one of such eminent public usefulness in several departments of activity, which he has efficiently promoted both by his scientific attainments and his marked executive ability, that no biographical sketch of him can be given that does not involve some account of the

various projects, measures, and reforms, with which he has become identified. Science is devoted to the interests of truth, but that truth is for the service of humanity; and the work of research becomes of the highest value only in its large Baconian application to the "relief of the estate of man." It is through the intelligent and well-directed efforts of such men as Dr. Chandler that the fruits of science are applicable for the large amelioration and advantage of society. It is, moreover by the substantial and lasting benefits thus gained that the community is led to recognize its great debt to science which it discharges by increasingly liberal provisions for its cultivation and development.

Professor Chandler was born at Lancaster, Massachusetts, in 1836. His father became a merchant in New Bedford, where he still resides. On the maternal side he is descended from the rebels of the Revolution and on his father's side from the Tories. His maternal grandfather was John Whitney, an old Boston merchant; his grandmother was a daughter of John Slack, who fought at Lexington. The Chandlers originated with William Chandler and Annis his wife, who arrived in Roxbury, Massachusetts, from England in 1637. It was at Lancaster, Massachusetts, in the house of his grandfather, Nathaniel Chandler, who graduated at Harvard in 1792, that Professor Chandler was born.

Hunting chiastolites and other minerals at Lancaster during vacations, and attending lyceum lectures and listening to the elder Agassiz, led him to take an early interest in scientific studies, and while still a boy he turned his workshop in the attic into a laboratory. After graduating at the high school, he continued his classical studies privately with a friend of the family for a year, and then pursued his professional studies at the Lawrence Scientific School, and the Universities of Göttingen and Berlin.

His teachers in chemistry have been Horsford, Wöhler, and Heinrich Rose. Through the influence of Wöhler and his friend Professor Joy he obtained the position of private assistant to Rose during the year he spent in Berlin, in whose laboratory his only companion, besides Rose and his lecture assistant Oesten, was the now famous Nils Erich Nordenskjöld, the Arctic explorer. In physics he studied with Weber, Dove, and Magnus; in mineralogy he attended the lectures of Professor Cooke at Harvard, Von Waltershausen in Göttingen, and Gustav Rose in Berlin. In geology he listened to the lectures of Agassiz. In 1856 he received his degree of Doctor of Philosophy and Master of Arts at Göttingen, publishing a dissertation containing the results of miscellaneous chemical investigations.

Soon after his return to America he accepted the position of assistant at Union College under his friend Professor Joy; and when, soon after, this gentleman was called to Columbia College, Chandler immediately succeeded to his duties, and began lecturing to the Senior Class, though not yet "of age"—politically. He remained here for eight years in charge of the laboratory, and lecturing to the col-

lege classes on general and agricultural chemistry, mineralogy, and geology.

In 1864 Professor Chandler became connected with Columbia College, joining Professor Egleston and General Vinton in the experiment of starting a School of Mines. The project originated with Professor Egleston, who, with his friend Vinton, had recently graduated at the École des Mines in Paris. It was not considered very promising, but the three professors were willing to begin without salaries. Mr. George T. Strong, W. E. Dodge, Jr., and several others, furnished about three thousand dollars to equip the modest laboratories. Hon. Gouverneur Kemble presented a fine cabinet of minerals. Dr. Barnard, the newly-elected President of Columbia College, Dr. Torrey, and the other Trustees, encouraged the enterprise in every possible way, and some vacant rooms in the basement of the college were assigned for laboratories. The success of the school was marvelous. Provision was made for twelve students; twenty-four came the first day. During the entire winter the carpenters and gas-fitters were constantly at work erecting new tables for additional applicants, and the number of pupils reached forty-eight. The Trustees of the College responded liberally. During the first vacation they placed a large four-story building at the disposition of the school, with ample funds for the equipment of laboratories and cabinets. Accommodations were arranged for seventy-two pupils. During the second year the school was thronged; eighty-nine students were in attendance. The success of the new school seemed so well assured that the Trustees arranged to place it on a substantial basis as a coördinate department of the college. Professor J. S. Newberry was called to the chair of Geology, relieving Professor Chandler of this subject, and a full faculty of professors and assistants was established. A new building was erected, and equipped with laboratory accommodations for one hundred and fifty pupils; these were outgrown, and a few years ago still larger ones were erected. The school is now in its sixteenth year; it has about two hundred and fifty students, pursuing a four years' course of study. Professor Chandler has been Dean of the Faculty of the School from the beginning, and has been the executive officer, besides having charge of the laboratories and giving his regular courses of lectures. The Assay Department was the especial hobby of Professor Chandler, and, with the aid of his successive assistants, Miller, Day, Blossom, and Ricketts, has been made the most complete of its kind to be found anywhere. To facilitate the work of assaying gold and silver ores, he devised an improved system of weights, which has been generally adopted by assayers.

When Professor Chandler first came to New York, he was asked to lend a hand in the development of the College of Pharmacy. This institution was then occupying a single room in the old University building on Washington Square, and numbered about thirty students.

Three evenings a week, all winter, Chandler lectured there year after year. The active exertions of the faculty and the trustees, and the interest manifested by the New York druggists, have built up from this small beginning a most flourishing school of three hundred pupils, which is able now to own a fine building, with laboratory and lecture-halls.

At the death of Professor St. John, Professor Chandler succeeded to his chair of Chemistry and Medical Jurisprudence in the College of Physicians and Surgeons, which he now holds. Here his voice has always been raised in favor of a much more exacting system of medical education, and has not been without effect, in the recent radical improvements which have been adopted in this institution, involving an extension of the session to seven months, written examinations, etc.

In 1866 Professor Chandler was invited by the Metropolitan Board of Health to do some gratuitous chemical work. He accepted the invitation, and so impressed the Commission with the importance of his work that, at the end of the year, they created the office of Chemist for him, which he held till 1873, when he was appointed by Mayor Havemeyer President of the Board. In 1877 he was reappointed, for six years, by Mayor Ely. As Chemist to the Board of Health, food and water supply were made the subjects of careful investigation. The absurdity of the annual complaints with regard to the quality of the Croton was clearly established, as was also the danger of drinking water from any of the city wells. It was also shown that the popular belief in the wholesale adulteration of the common articles of food, such as flour, bread, sugar, etc., was unfounded. The shameful condition of the milk-supply was pointed out, and it was shown that for every three quarts of milk there was added at least one quart of water, to say nothing of the frequent removal of a considerable portion of the cream. The fact that most of the condensed-milk companies skimmed the milk before they concentrated it and sold the cream separately was also published. A fraud on the citizens, amounting to at least ten thousand dollars a day, was traced to the milk-dealers.

After Dr. Chandler was made President of the Board of Health, he made the milk question his special study, and carried on a successful warfare against the dishonest dealers. He rightly assumed that, as milk was the chief diet of the one hundred and thirty thousand children in New York, under five years of age, it was the most important article of food for municipal supervision. His reforms were not accomplished without very sharp fighting. The milk-dealers organized, and secured the services of lawyers and chemists, who attacked both the laws and the chemical methods. After prolonged litigation, the Court of Appeals affirmed the ordinances of the sanitary code, and the lactometer as used by Dr. Chandler and his inspectors received the scientific endorsement of the best chemists in the country, including

Barker, Morton, Silliman, Caldwell, Goessmann, and many others, as well as the more practical endorsement of verdicts from the Judges of the Courts of Special Sessions and the jury of the General Sessions. At least fifteen thousand dollars has already been paid by milkmen in fines for watering and skimming milk. This investigation of the lactometer is important and interesting, for, while the Swiss and German investigators use it with the greatest confidence, the English analysts were shaken in their faith by the special pleading with which Wanklyn recommended his own method of analysis.

At the same time an investigation of the liquors sold in the commoner resorts was undertaken. The Metropolitan Excise Commissioners decided to withdraw the license of every one of the eight thousand dealers who should be found selling adulterated liquors. Professor Chandler was engaged to make the analyses on terms which might well have turned the head of any chemist. He was to receive twenty dollars for each analysis; there were eight thousand dealers, and there were likely to be three or four samples from each. But when he came to examine the first installment of forty samples of whisky, gin, rum, and brandy from Mulberry, Mott, Baxter, and other streets of that character, he was compelled to report that while the brandy was all factitious, and the basis of the others was common whisky, there was no adulteration in the sense of anything added of an injurious character. Some of them had been carelessly made and contained more fusel-oil than others, but the poisonous constituent was the alcohol. This ended the projected reform of the liquor-traffic by chemical analysis.

An effort was made to put a stop to the sale of poisonous cosmetics, especially the various preparations of lead salts which are employed either on the skin as a white enamel or upon the hair to restore the original color. His analyses were widely published.

The most important work of Professor Chandler was, however, the investigation of kerosene accidents, which were of very frequent occurrence, not only in New York, but wherever this cheap illuminator was used. It was supposed by the world at large that the accidents were an unavoidable incident to the use of the oil. Kerosene came in as a substitute for "camphene" or "burning-fluid," which was inherently dangerous and could not be made safe. Kerosene was supposed to be similar in chemical composition and properties, and the accidents were generally attributed to carelessness. In 1869 Chandler began his work on this subject, his first report to the Board of Health bearing date January 11th of that year. It was a simple statement of the chemical nature of petroleum and its products, explained the process for refining the oil, and clearly established the fact that the dangerous character of the oils in use was due to the fact that the refiners, in order to realize a profit of two or three cents per gallon, left a certain quantity of the highly inflammable naphtha in it. He also reported

the fact that he had purchased seventy-eight samples of oil from as many different dealers in the city, and not a single one of them was safe. Some were pure naphtha.

So convincing was the statement that it was taken up all over the country. The report was reprinted everywhere, and the statements were made the basis of legislative action in most of the States. The report was followed by a second in July of the same year, a third in 1870, and a very elaborate report of 110 pages in 1871. Ten thousand copies of the latter were printed and circulated by public-spirited citizens in New York. It was largely reprinted in Switzerland, extensively quoted in France and Germany, and freely used and quoted by the Select Committee of the House of Lords in their report on the Petroleum Bill, 1872. In fact, Professor Chandler was invited to go to England to testify before this committee. He did not content himself with writing on the subject, but lectured in the hall of Cooper Union, the Academy of Music, and in Washington. Not only were the dangers of poorly refined oil exposed, but also the entire failure of all the safety-oils, safety-lamps, safety-cans, vapor-stoves, etc., and patented processes for making naphtha and benzine safe. It was shown that, with proper oil, accidents would never occur, while there is no method by which bad oil can be used with safety.

In New York City alone there were, in 1870, a hundred and fifty-seven fires known to have been caused by kerosene and naphtha, eighteen per cent. of the whole. There were also twenty-one deaths from the same cause, with thirty-nine deaths from clothes taking fire in ways not stated. It was estimated that from one to two thousand persons were killed annually by these accidents, before the labors of Chandler called attention to the cause and indicated the remedy.

One of his most comprehensive investigations resulted from the action of the Board in suppressing the gas nuisance. All the gas companies purified their gas by what was called the dry-lime process. The foul lime when removed, as it was daily, from the purifiers, disseminated a stench throughout the entire city. This odor was by most citizens attributed to the sewers. When it was fully realized that it came from the gas-works, the companies were appealed to, and, with one exception, they introduced improvements by which the odor was suppressed. One company, however, maintained that no odor emanated from their works; that the odor was not disagreeable; that it was wholesome, as children suffering from whooping-cough were brought to breathe it; that they could not avoid making it; and, finally, if they did, the gas would be too bad to burn in dwellings. The result of these claims was a most elaborate trial before a referee. The gas company produced experts and other witnesses to sustain the above views, and Professor Chandler combated them with the best foreign authorities on gas-making. The evidence was subsequently published in the Report of the Board for 1869, and is one of the most

complete discussions of gas-purification which has ever appeared. The Board decided against the company, and the gas nuisance ceased.

As President of the Health Department of New York, Professor Chandler has held a most responsible position for the past six years. During this time he has had associated with him in his work Dr. S. O. Vanderpoel, the Health Officer of the Port, and Dr. Stephen Smith for the first two, and Dr. Edward G. Janeway for the past four years. These men have always worked in complete harmony.

The present Board of Health was organized under the charter of 1873, which was a modification of that of 1870, which abolished the Metropolitan Board. This latter was established in 1866, and a very perfect system of sanitary legislation and supervision was inaugurated by the health laws of that year. The Sanitary Code of New York was the first result of that legislation. New enactments have been made from time to time, and it is believed that New York City now possesses a more extensive and perfect system of sanitary supervision than any other city in America or Europe; and its laws and code, as well as its work in general, have been made the model for similar work throughout the country. When the present Board organized, it adopted a thorough civil-service system, and there has not occurred a single instance since that time in which it has been departed from. Dr. Chandler's first labors in 1873 were directed to the purification of the atmosphere of New York, and his first summer was spent in the most active warfare on all kinds of stench-producing trades.

The war was not confined to the land, as a naval engagement occurred on more than one occasion. At last there were no odors left save those which were wafted across the East River from Newtown Creek and Hunter's Point, and which the Board of Health was diligently combating when the farce of the indictment of its members was enacted by the grand jury.

Judge Sutherland promptly quashed the indictment on the ground that neither a moral nor a legal excuse existed for it. That the Health Board was not inactive is shown by the fact that suits were brought against the city for nearly five hundred thousand dollars for their acts in suppressing nuisances in 1873 and 1874; and that the members acted with judgment is shown by the fact that in every one of these suits they were victorious.

One of the most creditable acts was the removal of the two-story structures, which had been erected over the half of the roadway of the public streets adjacent to Washington Market, and almost entirely surrounding the block which the market occupies. Every effort had been previously made by other boards to remove them, but in vain. After exhausting every other method, the Board of Health in 1873 decided to use force, and one quiet summer evening Dr. Chandler led an army of one hundred and fifty carpenters and laborers, three hundred policemen, and a corps of surgeons to the market, and before

morning the entire line of buildings was leveled, and one of the most outrageous abuses that had grown up under political protection was abolished.

Among the numerous sanitary reforms secured by the present Board of Health, may be mentioned the system of gratuitous house-to-house vaccination established in 1874, which has already resulted in vaccinating over 360,000 persons, and the complete suppression of small-pox; the reform in the construction of tenement-houses; the employment of a special corps of fifty physicians during the five hot and damp weeks which occur in the latter part of July and the early part of August, and which were formerly so fatal to infants, killing sometimes eight hundred or one thousand in a week. The physicians make a house-to-house visitation, prescribe for the sick children, supply medicines, and distribute printed directions among the mothers. The Health Department in its varied work of recording the marriages, births, and deaths, preventing and caring for contagious diseases, disinfecting, sanitary inspection, and the abatement of nuisances, meat and milk inspection, employs a corps of one hundred and thirty men, besides the special summer corps of fifty physicians and the fruit-inspectors and extra disinfectors—requiring an annual appropriation of $250,000. The return for this large expenditure is seen in the remarkable improvement in the public health. In 1866, fifty-three per cent. of the total deaths were of children under five years of age. This percentage has steadily diminished, till it is now less than forty-six, which proves an actual saving of four thousand children's lives in a single year, to say nothing of all the sickness prevented in our population of over 1,100,000.

The sanitary chemistry of water has been a special subject of investigation with Dr. Chandler, and he has been relied upon to decide important questions with regard to the selection of water for supplying Albany, Yonkers, and several other cities. He has also been engaged in several important investigations on the pollution of water by factories, and the prevention of boiler incrustations.

During the past summer Dr. Chandler was made chairman of a committee to draw up a scheme for disinfection, to be adopted by the National Board of Health. The other members of the committee were Drs. Vanderpoel, Janeway, Henry Draper, Barker, and Remsen.

Professor Chandler's most elaborate chemical work has been the investigation of American mineral waters. With the aid of his assistants he has analyzed sixteen of the springs and artesian wells at Saratoga, besides many more sulphur and other springs at Chittenango, Florida, N. Y., and elsewhere.

Dr. Chandler, in connection with his brother, Professor W. H. Chandler, of the Lehigh University, started a monthly journal of chemistry, called "The American Chemist." It contained the results of many researches, and was a valuable periodical for those engaged

in chemical pursuits, but was not a success financially, and, after running six years with very considerable loss, it was discontinued. Professor Chandler has devoted much attention to chemical industries, and has written and lectured upon them frequently. He is often consulted by both manufacturers and the courts in regard to scientific questions involved in the arts.

Dr. Chandler is an effective popular lecturer, having an excellent voice, and a clear, direct, and vigorous style of delivery. His subjects chosen are those of technical and special interest, such as petroleum and kerosene accidents, water-supply, gas-lighting, prevention of fires, public health, etc., which are always practically and instructively treated. These lectures are of very great value, and, having been given in most of our principal cities, have exerted a wide and excellent influence. He has also been remarkably active as a writer. The list of his scientific papers is very comprehensive. It embraces the results of varied original investigations, covering wide ground, and making a catalogue too extensive for insertion here. He is the author of numerous scientific papers, cyclopædia articles, and addresses and reports, which have been published in the journals and proceedings of societies.

Dr. Chandler was President of the Convention that met at Northumberland in 1874 to celebrate the anniversary of the discovery of oxygen by Dr. Priestley. He published in full the interesting proceedings and addresses in "The American Chemist." The success of the Northumberland meeting led to the founding of the American Chemical Society, of which Chandler was one of the most active projectors, and of which he has been a Vice-President from the beginning, having refused the regular nomination for President almost every year since it was organized.

Besides the degrees of Doctor of Philosophy and Master of Arts, obtained as a student, Professor Chandler has received the honorary degree of Doctor of Medicine from the University of New York and Doctor of Laws from Union College. He is a life-member of the Berlin, Paris, and American Chemical Societies; he is also a member of the National Academy of Sciences, the London Chemical Society, the Sociedad Humboldt of Mexico, the American Association for the Advancement of Science, the American Philosophical Society, New York Academy of Sciences, and several pharmaceutical, sanitary, and other societies.

CORRESPONDENCE.

THE ORIGIN OF CRIMINAL LAW.

Messrs. Editors.

IN the very able article under the above heading, by Mr. W. W. Billson, published in your February number, I notice the following: "The law of the Allemans, which, while undertaking to enforce compositions for stale offenses, conceded to injured parties the privilege of righting themselves on the spot, and in the first transport of passion, finds a counterpart in the . . . . distinction made in the Twelve Tables between manifest and non-manifest theft. Persons detected in the act of stealing, or with the booty in their possession, were liable to the punishment of death . . . . while, if detected under other circumstances, they were only obligated to refund double the value of the stolen property."

Then, after some comments, the author quotes from Sir Henry Maine: "It is curious to observe how completely the men of primitive times were persuaded that the impulses of the injured person were the proper measure of the vengeance he was entitled to exact, and how literally they imitated the probable rise and fall of his passions in fixing the scale of punishment" (pp. 442, 443).

It may not be inappropriate to point out that a survival of the same feeling that gave rise to the practices quoted above seems still to be in force. There appears to be something of this sort in the custom that will hold a man blameless if he shoot and kill the midnight robber who is merely *trying* to *effect* an entrance into his house, but will not hold him guiltless if he take the same sort of vengeance on the robber after he has once *entered* the house, *stolen* the goods, and *escaped* with them. Surely the "*impulses*" of the injured person are allowed to have an influence here; for he may inflict much more severe punishment, by his own hand, in the first heat of his anger, upon him who is only attempting a crime, than he may inflict through the courts, after his anger has cooled, upon the successful perpetrator of crime.

CHARLES J. BUELL.

ROSENDALE, NEW YORK, *January* 19, 1880.

FROST-PHENOMENA.

Messrs. Editors.

READING the article in the March number of "The Popular Science Monthly," on the effects of frost in southern Russia in the winter of 1876–'77, reminds me of an unusual phenomenon at Vienna during the same winter. There were eleven days of perfectly uniform weather, the thermometer standing just above freezing in the daytime, with a fog, and a very faint southerly wind. At night it fell to just below, with bright starlight.

The result was that everything—houses, trees, lamp-posts, fences, statues—was covered with a stiff white hoar-frost on the windward side, and on this side only, the fine acicular crystals growing to a length of *five inches* on the trees, and of three or four on the iron and stone work.

The mass of crystals was always thicker at the end farthest from its support. A twig half the diameter of a pencil carried a fringe an inch thick at the edge. The crystals were horizontal, and so light that the twigs did not bend perceptibly beneath the weight. On the first warm day they were gone.

Very truly yours,

W. S. BIGELOW.

BOSTON, *February* 22, 1880.

EDITOR'S TABLE.

SOME FEATURES OF THE INTEROCEANIC CANAL QUESTION.

THE presence of M. Ferdinand de Lesseps in this country has precipitated the important question of a change in our national policy regarding an interoceanic canal across the American Isthmus. Let us briefly glance at the history of the subject, that we may understand the import of the new departure.

It is customary to rail at trade as a selfish and sordid occupation; but, as the laws of human development are better understood, it is found that the exchange and distribution of the prod-

ucts of human industry constitute one of the most powerful of all agencies of social amelioration and the improvement of the condition of mankind. The discovery of America, the greatest of all discoveries, may be said to have doubled the habitable world, and to have opened a new destiny for man upon earth; yet it was but an incident in the progress of commerce. The blind passion for wealth was the impulse that drove men to the exploration of the unknown globe; and, as often occurs in investigation, the search for one thing led to another of far more value and importance. To increase Oriental trade by finding a new and shorter route to the Indies was the object of Columbus; he discovered a new land, and died in the conviction that it was Asiatic, and that he had brought "the fabulous wealth of Ind" within the immediate grasp of Europe.

Yet, seven years after the death of Columbus, Balboa crossed the Isthmus of Darien and discovered the Pacific Ocean. So it was not India that had been reached, but a new world that had been found. The old problem, therefore, still remained, how to get to the Indies by a western route; but the question was now how to find a passage through. All navigators were alert in quest of a strait that should lead into the Indian Ocean, and the incentive that inspired the enterprise of Columbus animated his successors during half a century later. Prescott says that the discovery of a new and shorter route to the Indies "is the true key to the maritime movements of the fifteenth and the first half of the sixteenth centuries."

But, failing to find "the secret of the strait," men of enterprise began to think of cutting the knot by opening an artificial waterway for ships across the American Isthmus. The Spaniards led in this project of uniting the opposite harbors by a canal; and Galvao, in 1528, proposed to Charles V. to open a ship communication between the oceans at Panama. Plans and surveys were afterward made for this purpose. In 1534 Charles V. gave instructions to Cortez to seek such a route. In 1551 Gomara, author of the "History of the Indies," proposed three routes, including Nicaragua. In 1567 Antonelli was sent by Philip II. to explore with reference to a ship-canal. In 1795 William Patterson, founder of the Bank of England, and a man of comprehensive views, who had possessed himself of an extensive and minute knowledge respecting the institutions and commerce of foreign countries, obtained the royal sanction to a project for colonizing Darien, one of the objects of the enterprise being to cut a canal through the isthmus. The expedition was attempted, but proved a disastrous failure. During the next hundred years various projects were suggested, and explorations made by citizens of different countries with a view of overcoming this barrier to navigation; and in 1804 Humboldt gave a new interest and impulse to the subject by publishing a careful discussion of the relative merits of several routes for an interoceanic canal. As the commerce of the world increased in the early part of this century, the problem became still more urgent, and projects for solving it multiplied—Spain, France, Holland, England—all the leading maritime nations contributing schemes and projectors for the undertaking.

Thus, for three centuries and a half the question of piercing the American Isthmus has been universally recognized as a world's question, as the common interest of all nations, and as open to anybody who had the ability and the perseverance to accomplish it. For two hundred years before our nation came into existence this was the broad view taken of the enterprise in all countries; and, when the United States first became interested in the subject, it was also as a project concerning alike the whole civilized world.

So far as we learn, the first action

taken by the American Government in relation to this question was in response to an appeal from the Central American Republic. Señor Canaz, its Minister at Washington, in a note addressed to the Department of State in 1825, proposed the coöperation of that republic with the United States in opening a canal through the province of Nicaragua. Mr. Clay replied to it, and instructed Mr. Williams, then our Minister in Central America, to investigate the practicability of the Nicaragua route. Through Williams's influence a contract was made with the Central American Government for the construction of a canal through Nicaragua "for vessels of the largest burden possible." It was proposed to raise a capital of only $5,000,000 for the entire work; but even that amount could not be obtained.

The Central American Government then applied to Holland for coöperation, and a Dutch company was formed in 1830 to construct the canal; but owing to European political disturbances it could not carry out its agreement, and the Central American Republic renewed its application to the United States as the country that should naturally have the preference.

The project was again brought up under Jackson's Administration, and in 1831 Mr. Livingston, Secretary of State, instructed Mr. Jeffers, American *chargé* in Central America, as follows: "You will endeavor to procure for the citizens of the United States, or for the Government itself, if Congress should deem the measure constitutional and proper, the right of subscribing to the stock; and you will, in either case, present and transmit such plans, estimates, and other information relative to the projected work as may enable us to judge of its feasibility and importance."

Four years later, on the 3d of March, 1835, the Senate of the United States adopted the following broad and liberal resolution: "*Resolved*, That the President of the United States be respectfully requested to consider the expediency of opening negotiations with the governments of other nations, and particularly with the Governments of Central America and New Granada, for the purpose of effectually protecting, by suitable treaty stipulations with them, such individuals or companies as may undertake to open a communication between the Atlantic and Pacific Oceans by construction of a ship-canal across the isthmus which connects North and South America, and of securing for ever, by such stipulations, the free and equal right of navigating such canal to all such nations, on the payment of such reasonable tolls as may be established to compensate the capitalists who may engage in such undertaking to complete the work."

Again, four years later, in 1839, the American House of Representatives adopted a resolution reaffirming the ground taken by the Senate, and requesting the President to consider the expediency of negotiating with other nations "for the purpose of ascertaining the practicability of effecting a communication between the Atlantic and the Pacific Oceans by the construction of a ship-canal across the Isthmus, and of securing for ever, by suitable treaty stipulations, the free and equal right of navigating such canal to all nations."

The same policy was even more broadly and emphatically announced by the United States Government in 1850, in the Clayton-Bulwer Treaty. That convention contains the following declarations:

"The Governments of the United States and Great Britain hereby declare that neither the one nor the other will obtain nor maintain for itself any exclusive control over said ship-canal; agreeing that neither will ever erect or maintain any fortifications commanding the same or in the vicinity thereof, or occupy, or fortify, or colonize, or assume or exercise any dominion over

Nicaragua, Costa Rica, the Mosquito Coast, or any part of Central America; nor will make use of any protection which either affords or may afford, or any alliance which either has or may have to or with any state or people for the purpose of erecting or maintaining any such fortification." Moreover, that "vessels of the United States or Great Britain traversing the said canal shall, in case of war between the contracting parties, be exempted from blockade, detention, or capture by either of the belligerents; and that this promise shall extend to such a distance from the two ends of the said canal as may hereafter be found expedient to establish"; that "they will guarantee the neutrality thereof, so that the said canal may for ever be open and free"; and that they "will invite every state with which both or either have friendly intercourse to enter into stipulations with them similar to those they have entered into with each other."

This is solid American ground. These deliberate and explicit declarations of both Houses of Congress and of the treaty-making powers of Government must be taken as expressing the national conviction—1. That the construction of a canal at the American Isthmus is an open project to be entered upon by any "capitalists," "individuals," or "companies" that may undertake it; 2. That it is a great international work to be under the joint control of the nations; and, 3. That the international protectorate is to be secured by treaty arrangements which it is proper for the President of the United States to initiate.

This is the just and honorable historic position of the American Government, and, as we may fairly assume, of the American people, in relation to this great enterprise. It is a definite and explicit line of public policy which has been variously and repeatedly proclaimed without protest or dissent. We have recognized the great desirableness of the interoceanic canal for this country, and its importance to the world; and we have pledged the faith of the republic to coöperate with other nations in affording international security to whatever individual or company would carry out the work.

Ferdinand de Lesseps now comes forward and offers to construct the canal. He is no dreamer, but a man of action. He has had experience in this work, and means business. Fortified by the almost unanimous approval of a large convention, which represented the best engineering skill of the age, he has determined the plan and route of a canal that he thinks will best meet the demands of the future; and stakes his reputation upon its practicability. M. de Lesseps's character gives seriousness to the proposition, and probably brings the measure nearer a practical realization than it has ever been before. It is a question that can not much longer be postponed.

And now come grave intimations that the American Government is to reverse its historic policy on the Isthmian Canal question. The honorable and consistent ground it has hitherto maintained is to be abandoned, faith is to be broken, pledges repudiated, and treaties abrogated. The canal is not to be controlled by international law, and the coöperation of maritime nations, but it must be exclusively controlled by the United States. Whoever makes it, and whoever pays for it, we are to seize it and hold it whenever we please. A select committee of the House of Representatives on the Interoceanic Canal has unanimously recommended the immediate adoption of the following joint resolutions:

Be it resolved by the Senate and House of Representatives of the United States of America in Congress assembled:

That the establishment of any form of protectorate of any one of the Powers of Europe over the independent states of this continent, or the introduction from any quarter of a scheme or policy which would carry with it a right to any European Power to interfere with their concerns, or to control in any other man-

ner their country, or to transfer to any such Power, by conquest, cession, or acquisition in any other way, of any of those states, or any portion thereof, is a measure to which this Government has, in the declaration of President Monroe, in his message of December 2, 1823, and known as the "Monroe doctrine," avowed its opposition; and which, should the attempt be made, it will regard and treat as dangerous to our peace, prosperity, and safety.

2. *Resolved*, That it is the interest and right of the United States to have the possession, direction, control, and government of any canal, railroad or other artificial communication to be constructed across the isthmus connecting the American Continents, for the transfer of vessels and cargoes from the Caribbean Sea to the Pacific Ocean, whether the same be built or constructed at Panama, Nicaragua, or elsewhere; and, in view of the magnitude of this interest, it is the duty of the United States to insist that, if built, and by whomsoever the same may be commenced, prosecuted, or completed, and whatever the nationality of its corporators or the source of their capital, the interest of the United States and their right to possess and control the same will be asserted and maintained, whenever in their opinion it becomes necessary.

3. *And be it further resolved*, That the President be requested to take the steps necessary and proper for the abrogation of any existing treaties whose terms are in conflict with this declaration of principles.

There is, of course, no mistaking the significance of the position here taken. Whoever constructs the canal, and wherever the money comes from, this nation is to take possession of it and to maintain it. The newspapers have prepared us for this by declaring that the canal must be ours even at the cost of war, and though it be necessary to raise armies and navies to fight the whole world. Even so grave a journal as "The Nation" declares, and reaffirms in a subsequent issue, "Wherever and whenever it [the canal] is constructed it will become the most sensitive and vital part of our interstate and international commercial system, and we must be prepared to protect it from the evil of local revolutions and foreign aggression, to seize it when necessary, and successfully defend it against the two greatest naval powers in the world. The completion of such a canal involves, therefore, the creation and maintenance of a naval force in the Atlantic and Pacific capable of contending with that of any possible European combination." And here comes the "New York Tribune," formerly the champion of peace, industry, and the ascendancy of civil rule, but now viewing the Interoceanic Canal as first of all a question of war. International law, the honor of governments, and mere paper protectorates are disparaged, and our policy is proclaimed to be "the erection of American forts, manned by American soldiers, at the two mouths of the canal."

The pretext for all this is the "Monroe doctrine," reaffirmed in the first of the above resolutions. Let us see what this doctrine is, and how it has been perverted to base ends for which it was never designed.

When the career of Napoleon ended, and the legitimate kings of Europe were again restored to their thrones, there came a reaction in favor of "strong governments," that is, government by despotic coercion in opposition to free constitutional governments. This resulted in a propagandism of tyrannic rule. A Holy Alliance was formed, embracing Russia, Austria, Spain, Prussia, and France, which, under pietistic pretenses, aimed at the repression of free institutions. The spirit of revolt against Old-World despotism had spread widely in Central and South America; and Venezuela, New Granada, Mexico, Colombia, Peru, Guatemala, and Brazil had declared themselves free and independent. It was in the programme of the Holy Alliance to regain control over the revolted American colonies, and reëstablish the European system.

In this enterprise England did not join, nor did she at all approve of it. Mr. George Canning, the English Prime Minister, called the attention of the United States to the Continental plots, and asked if this Government intended to allow the subjugation of the

American republics by foreign Powers. In his next message President Monroe said:

> We declare that we should consider any attempt [of the allied Powers] to extend their system to any part of this hemisphere as dangerous to our peace and safety. . . . With the governments who have declared their independence and maintained it, and whose independence we have on great consideration and on just principles acknowledged, we could not view any interposition for the purpose of oppressing them or controlling, in any manner, their destiny by any European Power, in any other light than as the manifestation of an unfriendly disposition toward the United States.

This was a courageous and timely and most proper declaration, and it had its effect: the Continental despotisms abandoned their projects of interference. A revived Napoleon, indeed, revived the experiment in the case of Maximilian of propagating the European system on this continent; but it quickly ended in disaster, carrying Napoleon himself with it and turning France into a republic.

The emergency which called forth the declaration of this doctrine having passed away, it has since been used as mere political stock buncombe to cover unscrupulous projects which could not be openly and honestly defended. At first an expression of national dignity and justice in defense of the rights of the weak, it has been made the excuse for subverting the very objects it was designed to promote. Conceived and promulgated in the interests of freedom, it has been villainously pressed into the interests of slavery. When there was apprehension that Spain might in some future contingency give liberty to the blacks of Cuba, and thus endanger the American slave system by the contagion of moral example, the Monroe doctrine was invoked to forestall the humane possibility. Buchanan, of Pennsylvania, and Mason, of Virginia, fulminated the "Ostend Manifesto" to prevent "foreign interference on this continent," that slavery might be perpetual; and this in the name of the Monroe policy.

And now it is proposed again to pervert the Monroe doctrine to an end never dreamed of by its promulgators, and in point-blank subversion of its legitimate objects. We have already shown that, promptly following the Monroe declaration, came Congressional instructions to the President to open negotiations with other nations for the encouragement of all canal-constructors. It was then well enough understood that the Monroe doctrine was declared, to stop the extension of political despotisms, not to stop the free and beneficent extension of commerce. It was to prevent aggressive interference with young and feeble republics on this continent, that they may take their equal and independent place among the nations. In the exercise of its national rights thus affirmed, the Republic of Colombia has entered into arrangements to avail itself of foreign enterprise in constructing a canal through its territory. And now, forsooth, the loud proclaimers of the Monroe doctrine of non-interference propose to violate the principle by interfering with the right of Colombia to open a canal. The principle of the Monroe doctrine is not capable of any such application; it is the very bulwark of De Lesseps's enterprise. Originally designed to guarantee to Colombia her sovereign rights over her own soil, it now becomes a hypocritical pretext for invading and crushing her nationality.

Slavery and war are the surviving scourges of barbarism. The Monroe doctrine, having been used to fortify and prolong the curse of slavery, is now to be used to multiply the curses of war, and of war against the progress of peace-promoting commerce.

The sham reasons for defeating De Lesseps being out of the way, there is little difficulty in getting at the real motives of hostility to his project, as evinced by a large portion of the press and embodied in the Congressional resolutions. There are powerful rival in-

terests opposing him, which do not scruple in the use of false pretenses to stir up jealousy and prejudice in the public mind to defeat his enterprise. The Pacific Railroad managers of course oppose further facilities of transcontinental communication; and no one can question that they are at the bottom of much of the hostility to the canal which has found expression in the newspapers. Their case was lately presented in a very candid way by the "New York Evening Mail" as follows: "The people and the Government of the United States have made a tremendous investment in transcontinental railways, that not only bind the Atlantic and Pacific slopes together, but give to the commerce of Europe new and swift channels of communication with the East. In the midst of the terrible uncertainties and fabulous expenditures of civil war, American enterprise, lavishly aided by the Government, undertook the gigantic task of railway-building across the continent. While all branches of industry are still burdened by the taxation imposed during this heroic period, is it quite time for us to favor opening a water-way across the isthmus that would, when completed, become a serious rival for the business that is now partly and gradually recompensing our Government and people? And is it wise at present to aid in opening a channel that will be used by foreign vessels to drive our traffic from the Pacific, as it has been driven from the Atlantic? Are we not entitled to a considerable period of opportunity for reaping the advantages of our costly overland railways, and of the ocean commerce that has been stimulated into a great growth by those railways?"

There is another class of busy operators who are eager for a canal, but in their white-hot patriotism can not endure the thought of its construction by a "foreigner." It must be a purely American affair, in the hands of American contractors, American engineers, and the American Government. So "big a thing," with "millions in it," they think belongs to Americans. And who doubts that in the hands of our business experts it would prove such a bonanza of jobbery, such a placer of plunder as this continent has never seen! Where, indeed, should the series of railroad jobs, of court-house jobs, of State "Capitol" jobs, culminate, if not in a canal costing indefinite hundreds of millions, with indefinite time to build it, with the national Treasury to back it, and so far away as to defy responsibility! And who doubts that those "interests" have been vigilant and active in manufacturing that opposition to De Lesseps which has taken embodiment in the late Congressional resolutions?

In an article contributed by M. de Lesseps to the "North American Review" he says: "It is because the French law is more severe in enforcing the responsibility of directors, thereby more perfectly protecting the rights of shareholders, among whom the United States should be included, that it has been proposed to organize the company under the French law." Could there be a more valid reason for the enterprise being an abomination in the eyes of our "smart American operators," than the fact that the rights of the shareholders would be protected? It is well understood that the experiences of our transatlantic friends in certain of our railroads, our mines, and our repudiated bonds, have led them to be very chary of irresponsible American investments, and that the clamor about the Monroe doctrine and our filibustering designs is intended to frighten away foreign capital from the enterprise of M. de Lesseps.

The sharpers, adventurers, and plotting speculators of the country are a unit against the construction of the Panama Canal by the man who has constructed the Suez Canal, and who defies the world to show that a centime of the funds contributed to it was misappropriated or stolen. Those schemers

are well practiced in the arts of hoodwinking the public and of managing Legislatures. Will they be able to force the American Congress to repudiate the most honorable part of the nation's historic policy?

CONDITIONS OF EDUCATIONAL REFORM.

A CORRESPONDENT from Ann Arbor, Michigan, wants something more explicit and practical from the "Monthly" on the subject of scientific education. He says: "Can not you throw a little more light upon the best collegiate course of education for a young person who designs entering one of the professions of law or medicine? You constantly refer to the value of science as a factor in education and as often vigorously protest against the old or the present classical courses; now, can not you help many who have children to educate, by pointing out the best course? This is a practical question, brought home to thousands of your readers, and it presses upon them for solution. Can not we have something more than glittering generalities, and which will be a guide to those needing the information? Is it not time, in fact, to formulate the best course and to give in detail and in their logical order the studies best fitted for the proper development of the faculties?"

We often have communications like this from zealous and impatient educational reformers, who think there has been talk enough about scientific education, and that it is high time something were done. But they expect too much, and are looking for impracticable things. It is a great mistake to suppose that the object here sought is anywhere to be at once and fully attained. The idea will be slowly and partially realized wherever there is a sufficient number of persons in any community imbued with the proper convictions and feelings to carry it into effect. Such a work must inevitably be gradual, and there will be concessions and improvements just in proportion to the strength and persistence of the demand for them. Our schools, at present, fairly represent the average intelligence and aspiration, and are as good as the people can appreciate or will sustain. A portion of the community—and the numbers are increasing—insist upon more time for science in the lower schools, and more science in place of the classics in the higher schools: both requirements have already been widely yielded. There is a larger provision than formerly in many primary schools for elementary science; and the multiplication of scientific schools in connection with colleges, or independently, and the modification of the old curriculum with better chances for science in many other institutions attest a salutary change in obedience to the growing wants. As the public demand becomes more discriminating and urgent, institutions will improve.

The line of progress, therefore, consists in making existing schools better. They are not to be displaced, but liberalized, and the culture they give made more useful and valuable. There would be no difficulty in forming a rational curriculum, but public ignorance, educated and otherwise, has to be reckoned with in carrying it out, because schools have to be supported. The principles of a better education than we now have are sufficiently understood, and the men are not wanting who could give a receipt for making a college much superior to those now in operation. But, if our correspondent had furnished him a perfect ideal plan, and the whole Johns Hopkins endowment to execute it, he would break down in getting his teachers and trustees, and his establishment would fall to the level of what could be publicly approved. If he merely wants help to construct a liberalized modern curriculum, he will find abundant materials in such works on education as those of Spencer, Bain, and Johnnot.

But there is a good deal of prelimi-

nary work to be done before any such ideal can be embodied, and this is the very practical work of enlightening public opinion so as to bring it to bear in improving the existing educational system. There are great impediments to change. Institutions are conservative, and tend to assimilate and subjugate the men who officer them. The noisy reformer is generally quenched by an appointment. His ideals are dissipated in the presence of refractory facts. A great machine system of public instruction, established by the State, and supported by general taxation, is too strongly intrenched to be easily altered. It resists improvement by the inertia of established habits, by official sluggishness, and a foolish pride that will not acknowledge defects. That upon which millions have been spent, and out of which thousands get a living, is sure to be strenuously defended and carefully conserved. Reform must be forced from without, and nothing but a better instructed public opinion can give us better schools.

LITERARY NOTICES.

THE INTERNATIONAL SCIENTIFIC SERIES, NO. XXVIII.

THE CRAYFISH: An Introduction to the Study of Zoölogy, with 82 Illustrations. By T. H. HUXLEY, F. R. S. Pp. 371. New York: D. Appleton & Co. Price, $1.75.

THE purpose of this book will probably be better brought out by an inversion of the title so that it shall read, "The Study of Zoölogy as exemplified in the Crayfish." The work is a contribution to scientific education in the biological field, and conforms to the modern and now well-settled method of passing from the study of concrete details to the investigation of general principles. Instead of beginning with propositions which are the outcome of past inquiry concerning living things as a whole, the student, on the other hand, commences by making himself familiar with some one particular organism, and, having mastered the elementary facts by direct acquaintance and actual knowledge, he then uses this knowledge in extending the range of his studies to other organisms and their relations in the animal kingdom. Professor Huxley has taken the crayfish as the creature best suited for the accomplishment of this object. The information in relation to it is full and valuable, but the book has not been made merely as a monograph on the natural history of this crustacean. Its aim is to lead the student through a large portion of the field of scientific biology, in such a way that he will certainly and thoroughly know the subject; and the crayfish is chosen to attain this end because, all things considered, it is the best-fitted animal to do this. It would be misleading to represent this book as in the ordinary sense a popular one. It undoubtedly contains a good deal of information pertaining to natural history which will be read with general interest, but it was the well-defined purpose of the author in its careful preparation to make a book for biological students that should introduce them aright to the pursuit of their science, and, as the author says, they can only gain its intended advantages by going through the volume, "crayfish in hand." Immense labor has been bestowed upon the work in bringing it into its proper, simplified, and thoroughly methodical shape, and no doubt Professor Huxley could have written a work for the "International Series" with half the effort he has here expended. But he has chosen to avail himself of this channel of communication with different countries to give a new impulse and higher direction to the study of that comprehensive and most important science to which he has devoted his life. Mere book-education and half-knowledge he would, no doubt, admit to be better than nothing, but he would maintain that they are only tolerable as they tend to prepare for genuine and solid scientific acquisitions.

Huxley's "Crayfish" will at once become the text-book of classes which desire to enter the field of natural history by the right path; and it may be very strongly recommended to groups of young people forming clubs or voluntary classes to pursue the study by the method of self-instruction. It is a book, indeed, better suited than any

other we know for any young person, with a teacher or without, who wishes to get a right start in cultivating this branch of science.

THE REFUTATION OF DARWINISM AND THE CONVERSE THEORY OF DEVELOPMENT; BASED EXCLUSIVELY UPON DARWIN'S FACTS. By T. WARREN O'NEILL, Member of the Philadelphia Bar. Philadelphia: J. B. Lippincott & Co. Pp. 454. Price, $2.50.

OPPOSITE in every respect to Huxley's book is this volume of Mr. O'Neill upon an aspect of the same subject. Huxley's idea is that, when a man makes a biological book, he ought really to *know* something about the matter—to know it at first hand independently and authoritatively. But this man, who comes forward to put an end to Darwin, has no scientific credentials, but, quite the contrary, he reports himself as a member of the bar. That is, he is an advocate, a professional hireling, who first gets a fee and then argues accordingly. His vocation is not to search for truth by the methods of science, but to win cases by the methods of law-practice. Mr. O'Neill comes into biology as an attorney who proposes to show what dialectics is capable of by refuting Darwin with his own facts, and showing how he can work them all backward and establish a converse theory of development.

We gather, from a very hasty glance at his book, which is all that it is worth, that the author's position is this: He *assumes* the exploded doctrine of the fixity, or what he calls the normal immutability, of species—the old traditional doctrine that prevailed before the rise of modern biological knowledge. As man was created perfect and "fell," so species were created with a primitive "physiological integrity" from which they have become degraded. So the Darwinian progress, proved by Darwinian facts, is but a kind of atavism or reversion upward toward the recovery of lost characters. The book is ingenious from the lawyer's point of view, and makes merry throughout at the expense of Mr. Darwin's gross ignorance of the subjects to which he has devoted his life, but which become luminous in the hands of the man who really knows nothing about them. Another book is promised by the author, and meantime we recommend the present one to all young law-students, that they may see what they are in danger of coming to.

THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, under the Direction of Mr. N. H. WINCHELL. 1879. Pp. 123.

THIS survey was conducted during 1878 in the northern part of the State, and was devoted principally to the examination of the coast-line of Lake Superior from Duluth to the Pigeon River, for geological and lithological data. It was intended to give especial attention to mining interests, but very few persons were found to have any concern in them, and no actual mining is now done in the State. The zoölogical and botanical investigations were kept in abeyance, or carried only so far as possible without much additional expense. The ornithological section made, however, satisfactory progress, and a good account is given in the report of the plants of the northern shore of Lake Superior. A paper is appended by Mr. C. L. Herrick on the microscopic Entomostraca of the State, with twenty-one full-page plates of illustrations; the first attempt, the author believes, that has been made to describe these little crustaceans as a class.

THE KANSAS REVIEW. Vol. I., No. 1. November, 1879. Monthly. 75 cents per year.

THIS succeeds the "Kansas Collegiate" as the periodical of the students of the University of Kansas. Its scope will be more general than that of its predecessor; and it begins by having something to say on scientific and practical subjects. The number before us has signed papers on "Molecules," the comets of the year, and the college course, and the health of college girls.

THE CALIFORNIAN. A Western Monthly Magazine. Vol. I., No. 1. January, 1880. Pp. 100. Price, $3 a year.

THIS is a new periodical, of prepossessing appearance, published by the A. Roman Publishing Company at San Francisco. The first number offers a varied list of articles, among which "The Pacific Coast and Geodetic Surveys" and "Physical and Moral Influence of the Vine" are of scientific interest.

ZOÖLOGY FOR STUDENTS AND GENERAL READERS. By A. S. PACKARD, Jr., M. D., Ph. D., Professor of Zoölogy in Brown University. With numerous Illustrations. New York: Henry Holt & Co. Pp. 719. Price, $3.

DR. PACKARD has produced a superior text-book for the use of zoölogical students. It is considerably fuller than the ordinary manuals, and provides for pretty thorough study without taking rank among the voluminous and exhaustive treatises. The general reader will find much in it to interest him, but it has been prepared for the advantage of working students; and the author's purpose will only be attained as the learner uses the work to acquire a direct and actual knowledge of zoölogical science. The author thus states the objects he has had in view in preparing his books: "Should this manual aid in the work of education, stimulate students to test the statements presented in it by personal observations, and thus elicit some degree of the independence and self-reliance characteristic of the original investigator, and also lead them to entertain broad views in biology, and to sympathize with the more advanced and more natural ideas now taught by the leading biologists of our time, the author will feel more than repaid."

PROBLEMS OF LIFE AND MIND. Third Series. By GEORGE HENRY LEWES. Boston: Houghton, Osgood & Co. 1880. Pp. 500. Price, $3.

THIS volume contains all the remaining manuscript of the "Problems of Life and Mind" left by Mr. Lewes at the time of his death. Together with a small volume, published a year ago, it forms his contribution proper to psychology, though his "Physical Basis of Mind," in any extended view of the science, also forms a part. In the former volume the aim and scope of the science were considered, and in this the inquiry is carried a few steps into the science itself. The work opens with a discussion of the question of mind as a function of the organism, in which the distinctive views of Mr. Lewes, as to the nature of mind and its relation to the organized body in which its phenomena are manifested, are set forth with clearness, and some of the opposing views criticised with effect. The "sphere of sense and logic of feeling" occupies the author in the second problem of the work, and the like domain of intellect and the logic of signs is considered in the fragment of the remaining problem. Like all the works of this series, the present has the fault of too great diffuseness and unnecessary repetition, but it contains much that is valuable, many suggestive hints, and a good deal of strong thinking. Any examination of the positions taken by the work, or of their relation to the teachings of other psychologists, is impossible here, and nothing further need therefore be said save that students, to whom the subject is of interest, will find this, as all his other works, interesting throughout, and the exposition remarkably lucid.

THE YOUNGER EDDA. With an Introduction, Notes, Vocabulary, and Index. By R. B. ANDERSON. Chicago: S. C Griggs & Co. 1880. Pp. 302. Price, $2.

MOST people know something of the mythologies and traditions of Greece and Rome, of India and China; but few know anything of those of our Teutonic ancestors, the Norsemen. To bring before English readers the chief features of the theory of creation of these northern peoples, Professor Anderson has undertaken the translation of "The Younger Edda" of Iceland, contained in this volume. Together with "The Elder Edda" this forms a complete system of things. "The Elder Edda presents," says Professor Anderson, "the Odinic faith in a series of lays or rhapsodies," while "The Younger Edda contains the systematized theogony and cosmogony of our forefathers. The two constitute, as it were, the Odinic Bible." The translation is accompanied with very full notes.

ELEMENTARY LESSONS ON SOUND. By Dr. W. H. STONE. London: Macmillan & Co. 1879. Pp. 188. Price, 80 cents.

IN this little volume are given briefly the main facts of acoustics, with special regard to their relation to music, besides information that is properly intermediate and supplementary to both acoustics and music. It is clearly written and contains in a small compass a large amount of information.

A DICTIONARY OF GERMAN TERMS USED IN MEDICINE. By GEORGE R. CUTTER, M. D., Surgeon of the New York Eye and Ear Infirmary, Ophthalmic and Aural Surgeon to the St. Catherine's and Williamsburg Hospitals, etc. New York: G. P. Putnam's Sons.

THE student of scientific works written in foreign languages encounters many difficulties in the technical terms. They are not given in the ordinary dictionaries, or, if they are, it is as common words with common meanings, and not with any view to scientific correctness. The terms of German science are formed by the composition of native roots, and have no analogous forms in the scientific terms of other languages, and thus frequently offer a double difficulty. The meaning may be thought out, but it is often with risk to accuracy. In the absence of any German medical dictionary corresponding to Dunglison's dictionary, Dr. Cutter has been in the habit for twenty years of writing down the technical terms he met, and their definitions when they could be ascertained. He now publishes the results of these labors in this volume of three hundred double-columned pages of words and their definitions. Its value does not have to be proclaimed.

THEOLOGY AND MYTHOLOGY. An Inquiry into the Claims of Biblical Inspiration and the Supernatural Element in Religion. By ALFRED H. O'DONOGHUE. New York: Charles P. Somerby. Pp. 194. Price, $1.

THEOLOGY and mythology in this work are ranked together, and the writer maintains that they are both to be outgrown with the progress of knowledge. His point of view is thoroughly naturalistic; but the author protests that his book is written in no spirit of hostility to the religious sentiment of mankind. It seeks to get rid of manifest error, and is content with what remains.

POPULAR ROMANCES OF THE MIDDLE AGES. By Sir GEORGE W. COX and E. H. JONES. First American from second English edition. New York: Henry Holt & Co. 1880. Pp. 505. Price, $2.25.

THIS is a book of old mediæval legends and stories, the authors of which nobody knows anything about, and which have been revamped and thrown into the modern market. It is claimed that there is considerable new matter about Arthur and his Knights, and that the whole contents have undergone revision so as to make them acceptable to the taste of the readers of these times. The book contains the story of Merlin, Sir Tristram, Roland, Bewulf, Guy of Warwick, the Volsungs, and many others.

THE AMERICAN ENTOMOLOGIST. An Illustrated Magazine of Practical and Popular Entomology. Edited by C. V. Riley and A. S. Fuller, Washington, D. C. Published by MAX JAEGERHUBER, 323 Pearl Street, New York. Vol. I., New Series, No. 1. January, 1880. Pp. 24. $2 a year in advance.

PROFESSOR RILEY begins with this number a new series of "The American Entomologist." It will be, as it was before, practical and popular, and devoted not to entomology alone, but also to other branches of science so far as they are collateral or related to entomology. Arrangements will be made for the publication of local lists and purely descriptive matter as it may be furnished, without encroaching upon the space devoted to matter of general interest.

THE AMERICAN MONTHLY MICROSCOPICAL JOURNAL. Conducted by Romyn Hitchcock, F. R. M. S. Vol. I., No. 1. January, 1880. Pp. 20. $1 a year.

THIS takes the place of the "American Quarterly Microscopical Journal," and is intended to be an authoritative and trustworthy periodical for all persons interested in microscopy. Among the subjects which will be treated of at an early date is the detection of adulterations in food, and a translation of Eyferth's "Simplest Forms of Life," by the editor, is promised.

ECONOMICS OF INDUSTRY. By ALFRED and MARY PALEY MARSHALL. London: Macmillan & Co. 1879. Pp. 228. Price, $1.

THIS is an attempt to give in a concise form the outline of the science of economics as laid down by Mr. Mill, and as improved by writers since his time. It consists of a consideration of the laws of the production and distribution of wealth; such subjects as banking, foreign trade, and taxation being reserved for a future volume.

MÉMOIRE SUR LE FER NATIF DU GROENLAND, ET SUR LA DOLERITE QUI LE RENFERME. (Memorandum on the Native Iron of Greenland and on the Dolerite which incloses it.) By J. LAWRENCE SMITH, of Louisville, Ky. From the "Annales de Chimie et de Physique," Fifth Series, vol. xvi., 1879. Paris: Gauthier-Villars.

PROFESSOR NORDENSKJÖLD found in Greenland during his expedition of 1870 considerable masses of native iron inclosed in the dolerite rocks of Ovifak, in the Island of Disco. Several authors have regarded the metal as of meteoric origin, but Messrs. Johnstrup and Steenstrup, of Copenhagen, have expressed a different opinion, and M. Daubrée, of Paris, is in doubt. The present treatise describes the special studies of the author upon different specimens of the iron, and the conclusions he has derived from them. The iron is found inclosed in solid blocks in the mass of the dolerite. It is of different degrees of purity, some of the specimens being malleable and containing from 80 to 93 per cent. of metal, and others composed of the oxide, or of iron mixed with dolerite. From careful analyses of the specimens and an investigation of their constituents and surroundings, Mr. Smith comes to the conclusion that the iron can not be of meteoric origin, but is of terrestrial production, and originated in the secondary age.

DIE ENTWICKLUNG DES MENSCHEN-GESCHLECHTES. (The Development of the Human Race.) By Dr. ADELBICH STEINACH, of New York. Basel, Switzerland: Benno Schwabe.

THIS volume, though it has been the first to appear, is intended to be the second part of a work on the system of organic development. It considers the subject from the Darwinian but not from the materialistic point of view. It first regards man in his place in the world, in the mechanical and teleological aspect, afterward as related to the animals and as related to the individuals of his own species. Under the last head are given discussions of the differences among men and the manner in which they are formed, the hereditability of character and race-features, and the conditions and relations under which the propagation and spread of the race are carried on. The question of the unity of the species is considered as pertinent to this point. The place of man in time forms a second division of the subject; under it are discussed the origin of the race and the light thrown upon it by the earliest relics that have been discovered, and the centers from which the different families have spread. The development of intelligence is treated of in a third division, as related to culture, language, and civilization, the last head including the three subdivisions of development in religious and moral views and regulations, the development of social life and usages, and industrial and scientific efforts. The plan of the work is systematic, the method of treatment and the style are plain and straightforward, the thoughts are richly illustrated with citations of facts, and the manner is modest.

DAS BIER UND SEINE BEREITUNG EINST UND JETZT. FREIE ZYMOTECHNISCHE STUDIEN. (Beer and its Manufacture formerly and now. Free Zymotechnic Studies.) By HANS VON DER PLANITZ. Munich: R. Oldenbourg.

THE author of this monograph is a young man who received a part of his education in the United States, and has since been associated in scientific and practical operations in connection with brewing works in Germany. He has intended to give all that is known respecting beer, and has embodied in his not very large pamphlet a great amount of historical, technical, and statistical information. He traces the history of beer from ancient Egypt, where it appears to have been first mentioned, to Greece; and discusses the theory that it was carried to western Europe through Armenia, Scythia, and the Celtic and Teutonic migrations. The extent and condition of the manufacture and trade in the middle ages and the usages of the time in respect to them next come under view, after which we are brought down to the present, with its carefully studied processes and the recognition of beer as a staple article of production and consumption in nearly all countries. In this department the fruits of scientific studies are reviewed, the arguments for and against the use of beer are mentioned, and the place it occupies in the economy of the industrial and commercial world is defined. The statistical information is full and de-

tailed, and is given for every country in which beer is an important product, and separately for the different parts of Germany. The pamphlet is full of matter that is interesting even to those who have no other concern in the subject than that of curiosity.

THE BERKELEY QUARTERLY. Vol. I., No. 1. January, 1880. Pp. 80. $2 a year.

THIS is a new journal of social science, published by the Fortnightly Club, at Berkeley, California. Its purpose is defined to be to give public expression to the individual views of members of the Club on topics pertaining to society, to stimulate other persons to investigate such topics, and to furnish a suitable medium for the publication of papers upon them. The January number contains six papers on questions of government, the guidance of society, civil service, and related topics.

THE WORKSHOP COMPANION. New York: Industrial Publication Company. 1879. Pp. 158. Price, 35 cents.

THIS is a collection of such recipes, rules, processes, and practical hints as will be found of use in the workshop and the household. It has been the aim of the compiler to give only such recipes as he has tested and found reliable, and such information of processes and methods as will meet the needs of those concerned with them. The contents are arranged alphabetically, and as far as possible all information appertaining to any one subject is given under one heading.

BLOWPIPE ANALYSIS. By J. LANDAUER. Authorized English edition, by JAMES TAYLOR and WILLIAM E. KAY, of Owens College, Manchester. London: Macmillan & Co. 18mo, pp. 161. 1879. Price, $1.50.

THE author having been invited to prepare a German edition of Elderhorst's "Manual," his attention was drawn to the fact that in all works on the subject the chemical aspects were subordinated to the mineralogical. He determined to prepare a work from the chemical point of view, following only the peculiar and practical arrangement of Elderhorst. The translation has been printed under the personal supervision of the author.

UNITED STATES COMMISSION OF FISH AND FISHERIES. PART V. REPORT OF THE COMMISSIONER FOR 1877. Washington: Government Printing-Office. 8vo, pp. 981. With Plates. 1879.

THE report embraces, first, the result of inquiries into the condition of the fisheries of the seacoast and lakes of the United States; and, second, the history of the methods adopted for the introduction of useful food-fishes into its waters. The most important single fact ascertained by the Commission during the year was the existence on the whole coast of New England of a large flounder (*Glyptocephalus cynoglossus*), known in Europe as the pole or craig, an excellent food-fish, with the best qualities of the turbot, occurring in abundance and entirely unknown to the fishermen. Special attention has been given so far to the sea-salmon of the Atlantic and Pacific coasts, the land-locked salmon, the white-fish, the shad, the fresh-water herring, and the German carp. Attention will be given to the cultivation of the smelt; and it is hoped, some time, that specimens of the Oriental gourami, a useful fresh-water fish, will be added to the list. The most valuable and by far the largest part of the volume is occupied with the Appendix, more than half of which is taken up with a treatise on the menhaden and its products, amply illustrated, and a large part of the other half with papers on the cod, the cod-fisheries of the Loffoden Islands, and other fisheries of Norway.

GUIDES FOR SCIENCE-TEACHING. — The Boston Society of Natural History is publishing a series of guides for science-teaching, consisting of small pamphlet handbooks, each devoted to a special subject, with illustrations when they are called for. The books are designed as aids to teachers who wish to instruct their classes in natural history—not to be used as text-books—and give, besides illustrations and instructions as to the modes of presentation and study, hints for collecting, preserving, and preparing specimens. "Pebbles," by Professor Alpheus Hyatt, illustrates the way in which a common object may be used in teaching. "Concerning a Few Common Plants," by Professor Goodale, tells of the organs or "helpful parts" of plants, and how they can be cultivated and used in the school-

room for the mental training of children. Other books are "A First Lesson in Natural History," by Mrs. Agassiz; and "Commercial and other Sponges, and Common Hydroids, Corals, and Echinoderms," by Professor Alpheus Hyatt. Boston: Ginn Brothers.

THE REPORT OF THE COMMISSIONERS OF FISHERIES OF THE STATE OF CALIFORNIA FOR THE YEARS 1878 AND 1879 records the progress of the efforts to stock the rivers and lakes of the State with valuable fish; and gives also a report by Mr. W. L. Lockington upon the food-fishes of San Francisco. The introduction of salmon into the Sacramento River has been attended with great success. White-fish have thriven in the lakes. Seventy-four catfish from the Raritan River, planted in lakes near Sacramento in 1874, have increased to millions, and furnish an immense supply of food. Sacramento: State Printing-Office.

THE REPORT OF THE ENTOMOLOGIST OF THE UNITED STATES, DEPARTMENT OF AGRICULTURE, is largely occupied with the description of insects affecting the cotton-plant, and of the silk-worm and its culture. It also notices a considerable number of insects which are locally destructive to vegetation. Washington: Government Printing-Office.

A LECTURE ON PETROLEUM, ITS HISTORY, COMMERCIAL IMPORTANCE, USES, AND DANGERS, by P. SCHNEITZER, Ph. D., of the Missouri State University, embodies a great deal of information on the subject in a small pamphlet. Printed at Columbia, Missouri.

VOWEL THEORIES, by ALEXANDER GRAHAM BELL, describes investigations into the physiology of the formation of the vowels in the throat and mouth, and experiments with the phonograph, which were undertaken by Mr. Bell with reference to their bearing upon Helmholtz's theory of the harmonic composition of the vowel-sounds. New York: William Wood & Co.

"The Industrial News and Inventor's Guide." This is a new journal, edited by Mr. C. B. Norton, and is the organ of the American Industrial Exhibit Company (limited) of New York. It is a monthly magazine of twenty pages quarto, illustrated, the special object of which is stated to be to bring invention and capital together under favorable circumstances and at little expense. The first number is filled with matter relating to the Australian Exhibitions and new inventions. $2 per annum.

THE FORM OF SEEDS AS A FACTOR IN NATURAL SELECTION IN PLANTS, by ROBERT E. C. STEARNS, is an account of studies on the succession of predominant plants in the fields near the University of California, illustrating the advantages which burr-seeded or bearded-seeded plants possess in the struggle for existence.

ON METEORIC FIREBALLS SEEN IN THE UNITED STATES DURING THE YEAR ENDING MARCH 31, 1879, by Professor DANIEL KIRKWOOD, is an account of all the meteors observed during the time which were brought to the notice of the author, with the attendant circumstances and phenomena. Many of the descriptions were given by the observers personally; others are gathered from reports made where the meteors were seen.

INDIAN CORN, by E. LEWIS STURDEVANT, M. D., though brief, is an exhaustive treatise on the subject. It gives the botanical definition of the plant, its bibliography, its synonyms in all countries, its history and mythology in America, its European history, accounts of its original varieties and its minor variations, of the Indian cultivation, and of the products from the grain, and the classification of varieties, with numerous references to authorities. Among the special questions discussed is whether corn was not known in Europe before Columbus, having been introduced by the Northmen. It seems to have been known in China as early as the sixteenth century. Charles Van Benthuysen & Sons, Albany, N. Y.

PUBLICATIONS RECEIVED.

The Action of the United States Tariff. By Alfred Tylor, F. G. S. New York: G. P. Putnam's Sons. 1880. Pp. 16. 10 cents.

What Christians Believe. By Miles Gaylord Bullock, Ph. D. Syracuse, New York: Thomas W. Durston & Co. 1879. Pp. 218. 35 cents.

The Cause of Humanity. By Courtlandt Palmer. Published for the Society of Humanity, 141 Eighth Street, New York. Pp. 77. 25 cents.

An Epitome of the Positive Philosophy and Religion explanatory of the Society of Humanity, with an Important Letter of Harriet Martineau regarding her Religious Convictions. Published by the Society of Humanity, New York. Pp. 50.

Memorandum in regard to Instruction in the Mechanic Arts. By Edward Atkinson. 1879. Pp. 11.

Publications of the Cincinnati Observatory, No. 5. Micrometrical Measurements of 1,064 Double Stars. Cincinnati. 1879. Pp. 180.

Politics and Schools. By Sidney G. Cooke. Syracuse, New York: Davis, Bardeen & Co. 1880. Pp. 23.

Formation of Ground Ice in the Rapids of the Mississippi. By Dr. R. J. Farquharson. From "Proceedings Davenport Academy of Sciences," 1878. Pp. 6.

The Elements of Education. By Charles J. Buel. Syracuse, New York: Davis, Bardeen & Co. 1880. Pp. 25.

First Annual Report of the State Board of Health of Connecticut, for the Year ending November 31, 1878. Hartford, Connecticut. 1879. Pp. 112.

Suggestions on Rural Hygiene. Circular No. 5 of Connecticut State Board of Health. Hartford, Connecticut. Pp. 11. Illustrated.

List of a Collection of Aculeate Hymenoptera made by S. W. Williston in Northwestern Kansas, pp. 20; The American Bembecidæ, pp. 7; and Generic Arrangement of the Bees allied to Melissodes and Anthophora, pp. 9. By W. H. Patton. From the "Bulletin of the United States Geological Survey." Washington, 1879.

Antiseptics in Obstetrics and Gynæcology. By T. A. Ashby, M. D. Baltimore: Borst & Co., Printers. 1880. Pp. 13.

The Effect of Alum on the Human System when used in Baking-Powders. By Henry A. Mott, Jr., Ph. D. New York. 1880. Pp. 60.

On the Coincidence of the Bright Lines of the Oxygen Spectrum with Bright Lines in the Solar Spectrum, pp. 16; and On Photographing the Spectra of the Stars and Planets, pp. 7. By Henry Draper, M. D. Reprints from "American Journal of Science and Arts," October and December, 1879.

Catalogue of the Pacific Coast Fungi. Published under the Direction of the California Academy of Sciences. H. W. Harkness, M. D., J. P. Moore, A. M. 1880. Pp. 46.

Principal Characters of American Jurassic Dinosaurs. By Professor O. C. Marsh. Part III., with Six Plates. From "American Journal of Science," March, 1880.

Our Public Schools, in their Relation to the Health of Pupils. By J. T. Reeve, M. D. Appleton, Wisconsin. Pp. 27.

Our Schoolhouses. By Professor T. W. Chittenden. Appleton, Wisconsin. Pp. 26.

Annual Reports of the Inspector, Principal, and Physician of the Ontario Institution for the Education of the Blind, Brantford, Ontario, Canada. Printed by C. B. Robinson, Toronto. 1880. Pp. 22.

Report of Work of the Agricultural Experiment Station, Middletown, Connecticut, 1877–'78. By Professor W. O. Atwater, Hartford. 1879. Pp. 174.

Economic Monographs. No. VI. Free Ships. By John Codman. New York: G. P. Putnam's Sons. 1880. 25 cents.

Unity Pulpit, Boston. Sermons of M. L. Savage. Vol. I. No. 12. Morals and Knowledge; No. 13. A New Year; No. 14. Rights and Duties in Matters of Opinion; No. 15. Moral Sanctions; No. 16. The Religious Uses of the Imagination; No. 18. Religion, Public Education, and the State; No. 19. The Church and the Theatre; No. 20. Religion in Business. Boston: George H. Ellis. 1880. 6 cents per copy, or $1.50 a year.

Circulars of Information of the Bureau of Education. Nos. 1, 2, 3, 4, and 5. Washington: Government Printing-Office. 1879.

The Cotton-Worm. By Charles V. Riley, Ph. D. Bulletin No. 3, United States Entomological Commission. Washington: Government Printing-Office. 1880. Pp. 144. Illustrated.

Quarterly Report of the Chief of the Bureau of Statistics. Treasury Department of the United States. For the Three Months ending September 30, 1879. Washington: Government Printing-Office. 1880. Pp. 137.

Bulletin of the United States Geological and Geographical Survey of the Territories. Vol. V., Nos. 1, 2, and 3. Washington: Government Printing-Office. 1879.

Native Flowers and Ferns of the United States. Parts 17, 18, 21, 22, 23, 24, Vol. II. By Thomas Mehan. Illustrated by Chromolithographs. Boston: L. Prang & Co. 50 cents per part.

Around the World with General Grant. By John Russell Young. Parts 3 to 18 inclusive. New York: Subscription-Book Department of the American News Company. 50 cents per part. Pp. 64 each.

Introduction to the Study of Sign-Language among the North American Indians. By Garrick Mallery. Washington: Government Printing-Office. 1880. Pp. 68, with Illustrations.

Annals of the Astronomical Observatory of Harvard College. Vol. XI., Part 2. Photometric Observations. By Edward C. Pickering, Director, aided by Arthur Searle and Winslow Upton. University Press, John Wilson & Son, Cambridge, Massachusetts. 1879. Pp. 194.

Tenth Annual Report of the United States Geological and Geographical Survey of the Territories. By F. V. Hayden, United States Geologist. Washington: Government Printing-Office. 1878. Pp. 546. With numerous Maps and Engravings.

Half a Hundred Songs for the Schoolroom and Home. By Hattie Sanford Russell. Syracuse, N. Y.: Davis, Bardeen & Co. 1879. Pp. 108.

Four Lectures on Early Child-Culture. By W. N. Hailmann. Milwaukee, Wis.: Carl Doerflinger. 1880. Pp. 74. Paper, 25 cents; flexible cloth, 40 cents.

Eyesight, Good and Bad. By Robert Brudenell Carter, F. R. C. S. Illustrated. London: Macmillan & Co. 1880. Pp. 205. $1.50.

Key to Ghostism. By Rev. Thomas Mitchell. New York: S. R. Wells & Co. 1880. Pp. 240. $1.25.

A Handbook of Hygiene and Sanitary Science. By George Wilson, M. A., M. D. Fourth edition. Enlarged and revised. Philadelphia: Lindsay & Blakiston. 1880. Pp. 468. $2.75.

The Perception of Space and Matter. By Rev. Johnston Estep Walter. Boston: Estes & Lauriat. 1879. Pp. 451.

Sunshine and Storm in the East. By Mrs. Brassey. With upward of 100 Illustrations. New York: H. Holt & Co. 1880. Pp. 448. $3.50.

A Practical Treatise on Nervous Exhaustion. By Dr. George M. Beard. New York: William Wood & Co. 1880. Pp. 198.

A Forbidden Land. Voyages to the Corea. By Ernest Oppert. With 2 Charts and 21 Illustrations. New York: G. P. Putnam's Sons. 1880. Pp. 349. $3.

POPULAR MISCELLANY.

The Old River-Beds of Middle California.—Old river-beds are found in nearly all countries which have been affected by drift agencies. They are also found in California, but, while in other parts of that State they present general features similar to those of the Eastern States, those of the auriferous slate belt of middle California are entirely different in character and in their situation as respects the present river-beds, and are in some respects unique. In most other countries the present river-beds occupy the same position as the old; the rivers of middle California have been displaced by lava-flows from their former position, and compelled to cut entirely new channels. Instead of cutting these channels at a higher level than the older ones, as has been usually observed, the displaced rivers in California have cut them two or three thousand feet deep in the solid slate, leaving the old detritus-filled channels far up on the dividing ridges. In other parts of the United States the drainage system has remained substantially unchanged since Tertiary times, but in this California region the new drainage system is entirely independent of the old, having the same general direction, but sometimes cutting across it. The detritus in the old river-beds of California is composed of large pebbles and bowlders, instead of the silts generally found, and is capped by lava or other volcanic material. In these observations Professor Joseph Le Conte and Professor Whitney substantially agree. Professor Le Conte has made a further study of the phenomena, and has given his conclusions in a paper in the last number of the "American Journal of Science." The old stream-beds, as they are exposed in the processes of hydraulic mining, are shallow, lowest in the middle and rising to the sides, with such forms ground upon the surface of the bed-rock at their bottom as are always produced by swift currents carrying coarse materials, and are in marked contrast with the deep, sharply V-shaped cañons which characterize the present rivers in the same region. The filling up of the beds consists of a lower course, sometimes a few feet, sometimes many feet in thickness, of a conglomerate of pebbles and bowlders of considerable size, cemented with sand and a blue clay. Above this are alternate layers of pebbles, gravel, sand, and clay, with fragments or trunks of trees of the Pliocene age, and bones of the mammalia of the Pliocene and Quaternary ages, and perhaps human relics. Above the detritus is a capping of volcanic matter, a tufaceous conglomerate, with or without basalt over it. Professor Le Conte accounts for the singular phenomena by a theory, the principal features of which are that the old drainage system began to be formed after the birth of the Sierra Nevada, at the close of the Cretaceous period, and continued to exist through the Tertiary; the Sierra rose during the Glacial period, accumulated great masses of snow and ice and glaciers that were to play a part in filling the beds, and made the courses of the rivers much steeper than they had been before. The eruptions which threw out the volcanic products were preceded by a period of underground heat which melted the accumulated ice-masses. The waters and ice rushing in violent torrents brought down the coarse gravels and masses of rock, and dropped them as they became too great a load for the streams to carry. Afterward came the eruptions, first of ashes, then of lava, which flooded the mountain-slopes and completely obliterated the drainage system. Coincidently there were a considerable elevation of the Sierra range and an increase of the mountain-slope. The glaciers and rivers now began to cut a new system of channels independent of the old ones. They preferred the old divides, for the lava was thinnest or wanting there. As a necessary consequence of the increased elevation, the new channels were cut down to a level below that of the old ones.

Age of the Green Mountains.—Professor James D. Dana gives, in the "American Journal of Science" for March, his reasons for having in the new edition of his "Geology" referred the epoch of the formation of the Green Mountains—in the system of which he includes the whole region between the Connecticut and the Hudson—to the close of the Lower Silurian period. They are, when summarized: 1. That the western half of the region is proved to consist of rocks of the Lower Silurian age, and of one

orological system; 2. The schistose rocks of the eastern half, in Vermont, are to a large extent similar to those of the western; 3. The rocks of the central mountain section in Vermont are, in its northern part, identical schists with those on the east and west sides of it; 4. The western border of the region in the Hudson River Valley has its folded or upturned Hudson River (Lower Silurian) slates overlaid unconformably by the Niagara and Lower Helderberg (Upper Silurian) beds; 5. The eastern border of the region in the Connecticut Valley at Bernardston, in Massachusetts, Vernon, in Vermont, and the adjoining part of New Hampshire, has Lower Helderberg beds overlying, unconformably, folded or upturned roofing-slates (similar to those on the western side), the Lower Silurian age of which is not improbable; and at Littleton, in New Hampshire, and on Lake Memphremagog, in northern Vermont, occur unconformable Upper Helderberg (Lower Devonian) beds with fossils; 6. A mountain-individual of folded rocks—which is defined as comprising all the elevations or results of upturning or flexure that were produced over a continuous region in one mountain-making process—is necessarily one of great magnitude. Professor Dana does not consider his theory as established, for a further study of the stratigraphy of the eastern part of the region is required for that, but he believes that the facts, which he reviews in detail, are strongly in its favor.

Gas and the Electric Light.—The question of the feasibility of substituting the electric light for gas is yet far from settlement. The competition will be finally decided by the consideration of the relative expense, regard being also given to the quality of the light afforded. Some experiments which have recently been made for increasing the illuminating power of gas have been attended with satisfactory results. The most effectual devices are those by which a more perfect combustion is secured. By concentrating a number of burners so arranged as to play upon each other, and by improved arrangements for regulating and directing the draught of air upon them, the amount of light has been tripled, and it has been made clearer and more fixed. Burners constructed with this object in view have been tried in London, and found to give a considerable increase of light at a less increase of expense. Other devices, produced by French inventors, promise well. The inventors of electric lights seek either to produce single lights to supplement the defective illumination given by ordinary lights, or to divide the light, so as to make it take the place of gas entirely. The apparatus devised by Messrs. Regnier and Werdemann and Mr. Edison, for the latter purpose, give an agreeable light; but that is only a part of the problem. The difficulty of securing an economical production and supply of electricity remains, and that equally whether we seek to distribute it so that each consumer shall use only what he needs, or to store it in reservoirs of force. Experiments which have been made upon the amount of light produced per horse-power of motive force give greatly varying results. The light of M. Mersanne, with the Lontin machine, is rated at 80 carcels; the Jablochkoff light, with the Gramme machine, at 38 carcels; and Mr. Edison's machine, with 10 of his carbon lamps, at 16 carcels. A comparative trial of the strength of the Jablochkoff and Mersanne lights and gas was made in the latter part of December at one of the railway-stations in Paris. Six of the Jablochkoff lights, ten compound intensive gas-burners, and four Mersanne lights, were used. The brilliancy of the gas-light was to the Mersanne light as 1 to 5·67, and to the Jablochkoff light as 1 to 1·927. On direct comparison, the brilliancy of the Jablochkoff was to the Mersanne as 1 to 3. Roughly, 6 Mersanne lights were equivalent to 18 Jablochkoffs and 34 gas-jets.

Composition and Uses of Celluloid.—Celluloid, which has come into extensive use in the arts, is a species of solidified collodion, produced by dissolving gun-cotton in camphor with the aid of heat and pressure. From a description of its composition and mode of manufacture by Dr. W. H. Wahl, we gather the following: The process of preparing gun-cotton is well known; by it the properties of the vegetable fiber are so changed that it becomes soluble in alcohol and ether, as in making collodion, camphor, and other substances. In the process invented by the brothers Hyatt, gun-

cotton is ground in water to a fine pulp; the pulp is then subjected to powerful pressure in a perforated vessel, to extract the bulk of the moisture, but still leaving it slightly moist for the next operation, which consists in thoroughly incorporating finely comminuted gum-camphor with the moist gun-cotton pulp. The proportions employed are said to be one part by weight of the camphor to two parts by weight of the pulp. Any pigments, coloring matter, or other materials that may be adapted to the requirements of the articles into which the product is to be manufactured, may be incorporated at this stage. The mass is next subjected to a powerful pressure, to expel from it the remaining moisture, and incidentally to effect, also, the more immediate contact of the camphor with the pulp. The dried and compressed mass is next placed in a mold open at the top, into which fits a solid plunger, when a heavy pressure applied to the plunger is brought to bear upon the mixture. While thus under pressure, the mixture is heated to a temperature of about 300°, at which temperature the camphor fuses, and, its volatilization being impossible, the melted camphor dissolves, or "converts," the gun-cotton pulp. The process of transformation is rapidly effected when the right temperature is reached, and the product is celluloid. After the mass is taken from the press it hardens and becomes tough and elastic. A noteworthy circumstance is, that a large portion of the camphor appears to be permanently held in the mixture, so that its property of volatilization, when exposed to the air, is arrested. Celluloid is so extensively used as a substitute for ivory that it is said to have seriously affected the business of ivory importers and workers. It has all the strength and elasticity of this substance, and does not warp or discolor with age. It is used in place of tortoise-shell, malachite, amber, pink coral, and other costly and elegant materials, which it is made to imitate very closely. Its latest use is in combination with linen, cotton, or paper, for shirt bosoms, cuffs, and collars.

Experimental Glaciers.—Mr. J. T. Bottomley describes in "Nature" a successful experiment which has been arranged by himself and Mr. D. Macfarlane for constructing a model glacier with shoemaker's wax. A little wooden ravine was prepared, with steep declivities and gentle slopes, and a point where the space was narrowed by projections inward. At the upper end of the ravine a flat place was fixed, on which shoemaker's wax was piled, as snow collects at the upper end of the natural ravine. A supply of shoemaker's wax was put on the top at the beginning of each winter's session, whence a flow of semi-solid material went on steadily during the session, hardly perceptible from day to day, but progressing from week to week and from month to month. Several of the glacial phenomena were beautifully imitated with the wax; among them the more rapid flow of the middle with the less rapid flow at the edges. Little *crevasses* were sometimes formed, though not often, owing to the great effect of temperature on the plasticity of the material. Sir William Thomson, in order to test the qualities of shoemaker's wax as a viscous material, a year ago prepared a large cake of it, at the bottom of which he put some corks, and on the top some bullets. The corks at the end of the year had floated up through the wax, and were coming out at the top, while the bullets had sunk down and come through the bottom; and, while this was going on, the wax was all the time in such a condition as to be excessively brittle to any force suddenly applied.

Source of the Niger.—Information has reached Marseilles of a successful journey to the source of the Niger, which has been made by two men in the employment of the commercial house of M. Verminck, of Sierra Leone. The expedition, it appears, originated with M. Verminck himself, who sent forth two of his clerks, MM. Zweifel and Moustier, with an equipment of surveying instruments, maps, and goods, for the express purpose of reaching the spot on the northern side of the Kong Mountains, some two hundred miles from Sierra Leone, where both Major Laing, in 1822, and Winwood Reade, in 1869, were informed by the natives lay the sources of the "Joliba." The two envoys ascended the river Rokelle to the foot of the mountains, and seem to have met with none of that opposition, from

the chief of the important town of Falaba, which defeated the attempts both of Laing and Reade to reach the sources. The crossing of the mountains appears, however, to have been a difficult undertaking, not accomplished without much determination, aided by good luck. The main source was found on the frontier of Kirsi and Koranka; in short, near the place indicated on Major Laing's map.

Animal Heat of Fish.—Surgeon J. H. Kidder, of the United States Navy, made some observations during last summer in connection with the United States Fish Commission at Provincetown, Massachusetts, to test the belief which is still held by many, even scientific observers, that fish are cold-blooded—that is, that they take on the temperature of the water which surrounds them, with no power to resist it, and that they develop little or no animal heat themselves. Observations made in the usual way, by inserting the thermometer into the rectum of the fish, agreed with the generally received opinion, the fish showing in that part but little higher temperature than that of the surrounding water. It was judged, however, that neither the rectum, which is closely exposed to the water, nor the arterial blood, which has passed through the gills where it is exposed and cooled, could have the same value as representing the body-temperature in fishes that corresponding parts possess in mammals and birds, but that the degree of heat actually developed in the life-processes should be sought in the venous circulation and the branchial artery. The fish were accordingly opened as soon as possible after they were taken out of the water, and the bulb of the thermometer was inserted into the cavity of the heart, or the branchial artery. Most of the fishes showed a perceptibly higher temperature than that of the water, rising, in the case of the dogfish, to 12°. A young dogfish, taken from its mother's oviduct, was 20° warmer than the water. The number of observations was not large enough to warrant a final statement of the degree of animal heat presented by the several fishes, but they are held to prove that fish develop sufficient heat to warm again, to the extent of from 3° to 12°, blood that has been cooled in each circuit to the temperature of the surrounding water. An apparent exception to the general result was offered in the case of bluefish, which were cooler than the water; but that was supposed to be because they had come up from a greater depth and a colder stratum of water than that on the surface.

Sun-Spots and Rainfall.—Mr. E. D. Archibald writes in "Nature" that, instead of changes in the condition of the sun necessarily affecting every part of the earth in the same way, we have many meteorological analogies which favor the notion that totally opposite effects may arise in different parts of the earth from the action of the same primary causes. Thus, it is generally assumed that the same tropical heat which gives the primary impulse to the desiccating northeast trade-wind of subtropical latitudes, furnishes the energy which exhibits itself in the almost constant precipitation under the equator. Any variation in the degree of this heat should consequently affect places in the region of the trades and in the equatorial calm-belt, in a diametrically opposite manner. The great rainfalls of last autumn in England and India were ascribed by some to the sun's emergence from a period of years marked by the rarity of its spots, and shining with increased radiations on the southern oceans; but Mr. Archibald shows that the rainfall of England, between latitudes 50° and 55° north, reached a decided maximum in 1877, a year of extreme spot-minimum, and was very high all through the recent period of unusually marked spot-minimum. A table of the annual mean range of barometric pressure at Calcutta from 1840 to 1878, of which Mr. Archibald gives a summary in his communication, indicates that years of few sun-spots were characterized by higher temperatures, greater wind-velocity, and greater range of barometric pressure than those of many spots.

New Bleaching Preparation.—A method of applying the ordinary bleaching agents (hypochlorites) in a new way has been invented by Count Dienheim de Brochocki, of Paris. Instead of immersing the goods to be bleached in an ordinary "chloride-of-lime" vat, and subsequently scouring, the inventor

treats bleaching-powder with an acid, and simultaneously passes air through the mixture, so that chlorine and hydrochlorous acid vapors are mechanically carried off; the resulting gases are passed through an alkaline solution in such proportions as to saturate part or the whole of the alkali, or to supersaturate it at will. The resulting liquid is said to be sufficiently stable to be kept without change for two or three months; it can readily be prepared of a density of 30° Beaumé, and acts as a bleacher without requiring any acidulation, and for many purposes is said to be superior to the ordinary bleaching-vat. The new product, to which the inventor has given the faciful name of chlorozone, is used to a considerable extent in Paris, and works for its manufacture on a large scale have been erected at Warrington.

Effects of Excessive Tea-drinking.—W. J. Morton, M. D., of New York, gives in the "Journal of Nervous and Mental Disease" an account of investigations which he has made on the toxic effects of tea. They were carried on in the cases of five tea-tasters suffering from disease who came under his care, and in observations of his own symptoms during a week in which he subjected himself to special treatment with tea for purposes of experiment. From the whole series of observations he draws the conclusions that—1. With tea, as with any potent drug, there is a proper and an improper dose; 2. In moderation, tea is a mental and bodily stimulant of a most agreeable nature, followed by no harmful reaction. It produces contentment of mind, allays hunger and bodily weariness, and increases the disposition and the capacity for work; 3. Taken immoderately, it leads to a very serious group of symptoms, such as headache, vertigo, heat and flushings of body, ringing in the ears, mental dullness and confusion, tremulousness, "nervousness," sleeplessness, apprehension of evil, exhaustion of mind and body, with disinclination to mental and physical exertion, increased and irregular action of the heart, increased respiration. Each of the above symptoms is produced by tea taken in immoderate quantities, irrespective of dyspepsia, or hypochondria, or hyperæmia; 4. Immoderate tea-drinking, continued for a considerable time, with great certainty produces dyspepsia; 5. The immediate mental symptoms produced by tea are not to be attributed to dyspepsia; 6. Tea retards the waste or retrograde metamorphosis of tissue, and thereby reduces the demand for food. It also diminishes the amount of urine secreted; 7. Many of the symptoms of immoderate tea-drinking are such as may occur without suspicion of tea being their cause, and we find many people taking tea to relieve the discomforts which its abuse is producing.

Antiquity of the Tobacco-Pipe.—The discovery of large numbers of pipes, apparently of considerable age, in Great Britain and parts of the Continent of Europe, has given rise to new and extravagant conjectures as to the antiquity of the tobacco-pipe in Europe. From an article in "The American Antiquarian," by Mr. Edwin A. Barber, we learn that these ancient pipes are very small, and are found in great numbers in the British Isles, where they are known as fairy-pipes, Celtic or elfin pipes, Dane's pipes, Mab pipes, old man's pipes, and Carl's pipes. A number of them have been found so near to Roman remains as to induce the belief that they are Roman relics; but other undoubtedly modern remains have been found in a similar connection. The pipes resemble modern ones in shape, and often bear manufacturers' marks, which make it practicable to estimate their age. The oldest of them are supposed to have been made during the reign of Queen Elizabeth. Probably the oldest illustration of a tobacco-pipe in Great Britain is in a carving on a chimney in the keep of Cawdor Castle, where among the devices are a mermaid playing the harp, a monkey blowing a horn, a cat playing a fiddle, and a fox smoking a tobacco-pipe. This stone bears the date of 1510. Mr. Jewitt suggests, in his "Ceramic Art in Great Britain," that herbs and leaves were smoked medicinally long before the period at which tobacco is believed to have been introduced, and that pipes may have been in use for this purpose before "the weed" was known. British pipes may be classified according to age, with some degree of certainty; by form, as they

were developed from exceedingly small pipes with flat heels to larger barrel-shaped pipes, and then to pipes with long handles and pointed spurs. The makers' marks were put on the heels of the oldest specimens, on the bowls of more recent ones, and on the stems of still later ones.

Stammering and its Causes.—M. Chervin, founder and director of the Institution for Stammerers, at Paris, has recently made researches into the prevalence of stammering in France, as shown by the reports of the recruiting officers for the army during the last twenty years, and into the climatic and other influences that are favorable to the development of the infirmity. He has represented the results of his inquiries by a map which exhibits the relative number of stammerers in each of the departments at a glance. The map shows that the country may be divided into two distinct parts, by a line running from Bordeaux to Geneva, on the south of which the number of stammerers is vastly greater than it is on the north of it. The proportion of stammerers to the whole number of young men who have reached the age when they are liable to conscription appears to be about five to one thousand. The districts along the Mediterranean coast seem to be the most liable to the affliction; and it has been found that stammering is also extraordinarily frequent in Piedmont, which has a similar climate and population. M. Chervin attributes the origin of the habit in this region partly to the extreme animation of the speech of the southern people, partly to the hot winds which are the cause of nervous disorders with which stammering may be connected. Stammering may be produced by a sudden fright suffered during childhood. Sometimes the habit comes on gradually, or is developed by association with stammerers. Men appear to suffer more from it than women, as all authors agree, so that out of a hundred stammerers hardly more than ten or twenty will be women. This may, however, only signify that men feel more inconvenience from the evil and notice it more. The reports of the recruiting officers show that the proportion of stammerers is three or four times less in the cities than in the country; a fact that is very suggestive by the side of another which M. Chervin has brought out, that stammerers are most rare where there are the most schools. It is evident that as youth become more accustomed to using their language and learning to distinguish words, to spell and write them, they learn to have a clearer conception of them, to articulate more distinctly, and escape confusion. The great number of stammerers in savage countries has been observed by travelers. It is ascribed to the absence of a knowledge of their language, and to the frequent repetitions of the same syllables which appear in their words.

Investigating the Lightning-Rod.—Delegates were appointed in the summer of 1878, by a number of British societies, to consider the possibility of formulating the existing knowledge on the subject of the protection of property from damage by electricity, and the advisability of preparing and issuing a general code of rules for the erection of lightning-conductors. These delegates have held several meetings, and have already collected a large amount of information. Several of their number are also engaged in forming abstracts of the literature of the subject. In order that their report may be as trustworthy and exhaustive as possible, the delegates ask, through Mr. G. J. Symons, their secretary, for information to be communicated to them by correspondence, on the following points: "Full details of accidents by lightning, stating especially whether the building struck had a conductor or not. If there was a conductor, state its dimensions, construction, mode of attachment to building; whether its top was pointed, distance of its upper terminal from the place struck, nature and extent of the connection between the conductor and the earth, and whether the earth was dry or moist; whether the conductor was itself injured, and whether the conductor or the point struck was the most salient object in the vicinity. Information is also desired, either verbally or by sketches, as to the position of metal spouting and lead roofing relatively to the point struck, and to the conductor. Details of the thickest piece of metal melted by a flash of lightning are much needed. Unimpeachable evidence of the failure of conductors is much desired, as such failures would be extremely instructive."

NOTES.

MR. JAMES W. MILNER, Deputy United States Fish Commissioner, died at Waukegan, Illinois, January 6th, aged forty years. He was born at Kingston, Ontario, grew from the age of five to manhood in Chicago, was, even as a child, exceedingly studious, and is said to have injured his health in this way in early life. He had a special fondness for natural history, and first won attention as a student of science in early manhood by publishing accounts of researches made in Minnesota and adjoining States. In 1871 he received the appointment of Deputy Fish Commissioner, and was afterward, until his death, mainly occupied in the study of fish-culture, on which subject he was considered the best-informed man in the country. Most of his work was done in the West, on the fish of the Great Lakes, his researches on the breeding, mode of life, and food of the white-fish being especially valuable.

DR. PASQUAL BEAUVILLE, of Havana, in a report presented to the Havana Committee of the National Board of Health, describes a disease of dogs and horses occurring there which he names acclimation or yellow fever. An ailment with similar symptoms, and called bilious or yellow fever, was described some years ago as attacking the horses in Leith, Scotland. Dr. George W. Sternberg, of the United States Army, gives an abstract of Dr. Beauville's report in the "Bulletin of the National Board of Health," and also the symptoms of the disease observed in Leith, from which he concludes that both refer to one and the same affection, but this was not yellow fever as it occurs in man. He says, "While there are doubtless some striking points of resemblance, the pneumonia and enteritis described by the doctor are so prominent in the record of symptoms and pathological lesions as to give a special character to the disease quite different from that of yellow fever in man."

THE committee appointed by the French Minister of Public Instruction has awarded the Volta Prize of 50,000 francs, or $9,500, to Mr. Graham Bell.

AN extraordinary prize of 3,000 francs (about $600) has been awarded, by the French Academy of Sciences, to Professor Crookes, F. R. S., in recognition of his recent discoveries in molecular physics and radiant matter.

THE Council of the London Entomological Society has offered a prize of £50 (or $250) for the best and most complete life-history of *Sclerostoma syngamus*, supposed to produce the so-called "gapes" in poultry, game, and other birds; and another prize of £50 for the best and most complete life-history of *Strongilus pergracilis*, supposed to cause the grouse-disease. No life-history will be considered satisfactory unless the different stages of development are considered and recorded. The competition is open to naturalists of all nationalities. Essays in English, French, or German may be sent in on or before October 15, 1882.

IN a paper read before the French Academy of Sciences on the variations in the force of the action of the heart, M. Marey has observed that the force increases as the heart is full. On this principle he accounts for what takes place when an obstacle to the current of the blood raises the arterial pressure and creates a greater resistance to the action of the heart. The heart slackens its movements; in consequence of this relaxation the ventricle has more time to fill up, and really fills up more; it is then, at the beginning of its new beat, endowed with greater force, and is capable of surmounting a resistance which it could not have overcome if it had been less full.

A SINGULAR occurrence is reported to have taken place lately at Leck, in the grand duchy of Nassau. During a severe storm in the night the electric discharge fell into a fish-pond stocked with several species. On the next morning the fish were all found at the top of the water, dead. Their appearance was like that of boiled fish, and their meat fell to pieces when it was handled just like the meat of cooked fish. No hurt, either internal or external, could be perceived; the scales were not bruised, and the swimming-bladder was preserved still full of air. The water was disturbed and muddy at the time, as if it had just been stirred up.

MR. M. REYNOLDS, in a paper read before the London Association of Foreman Engineers on practical engine-driving, referred to a source of danger on the locomotive which is, perhaps, more important even than that arising from color-blindness. This is the blinding effect of the glowing white light of the engine-fire, a brief glance into which, he said, renders the person who has looked for a time unable to recognize the colors of the signal-lamps.

THE death is announced of Professor David Thomson, for thirty-five years Professor of Natural Philosophy in the University of Aberdeen. He was the author of papers on "The Velocity of the Waves of the Sea" and "On Double-Cylinder Pumping-Engines."

M. WALFERDAN, the inventor of the minimum thermometer, died in Paris near the end of January, at the age of eighty-five.

INDEX.

PAGE

About Snakes 571
Africa, Population of 426
Algeria, Cost of the Proposed Lake in 139
Ancient Methods of Filtration 495
Ancient Uses of Cork 429
Animal Mounds in the Pyrenees 135
Animal Transformations, New Views of. (Illustrated.) 625
Anthropometric Observation 431
Anthropology, Recent 145
Antiquity of Man 572
Arago's Statue, The Inauguration of 114
Archæopteryx, Carl Vogt on the 136
Arithmetic, Early Methods in 204
Arsenic in Kindergartens 694
Arsenic in the Household and School 715
Artesian Wells and the Great Sahara 580
Association of Ideas. (Illustrated.) 577
Astronomical Discoveries, Announcement of 715
Athletics in Schools 677
Atlantis, On 266
Authorship, Intellectual Straining in 93

Bain, Alexander, On John Stuart Mill 25, 311, 501
Bain on the "Data of Ethics" 210
Bennett, A. Hughes 519
Billson, William W., on the Origin of Criminal Law 433
Bird-Reasoning 139
Bolton, Professor H. Carrington 495
Books noticed:
"Ethics of Science and Duty" (Bascom) 125
"Freedom in Science and Teaching" (Haeckel) 127
"Geological Survey of Ohio," Vol. III 129
"Distribution of Heat in the Spectra of Various Sources of Radiation" (Jaynes) 130
"A Defense of Philosophic Doubt" (Balfour) 130
"The Science of the Bible" (Woolley) 131
"Nests and Eggs of American Birds" (Ingersoll) 131
"The Evidence of the Senses" (Stevenson) 131
"Haeckel's Genesis of Man" (Ward) 132
"Easy Lessons in Popular Science" (Monteith) 133

Books noticed: PAGE

"Hints toward a National Culture" (Boyce) 133
"Scientific Lectures" (Lubbock) 133
"Science Lectures at South Kensington" 133
"Zoölogy of Invertebrate Animals" (Macalister) 133
"Gray's Botanical Text-Book" (Gray) 277
"Hygiene and Public Health" (Buck) 279
"First Lines of Therapeutics" (Harvey) 281
"Neurility" (Clevenger) 282
"Is Life worth Living?" (Mallock) 417
"Naval Hygiene" (Wilson) 418
"Silk Goods of America" (Wykoff) 419
"Geology of the Lower Amazonas" (Derby) 421
"Primitive Manners and Customs" (Farrer) 421
"Papers read before the Pi Eta Scientific Society of Rensselaer Polytechnic Institute" 422
"American Ornithology" (Wilson and Bonaparte) 422
"The Rosicrucians" (Jennings) 423
"Antiquities and Platycnemism of the Mound-Builders of Wisconsin" (De Hart) 423
"The Silkworm" (Riley) 423
"Geology of the Diamantiferous Regions of the Province of Parana, Brazil" (Derby) 423
"First Step in Chemical Principles" (Leffman) 424
"Young Folks' Cyclopædia of Common Things" (Champlin) 424
"Inorganic Chemistry" (Valentin) 424
"The Value of Life" (Anonymous) 424
"Octavius Perinchief" (Lanman) 561
"Arctic Voyages of Nordenskjöld" 563
"Illustrated Dictionary of Scientific Terms" (Rossiter) 564
"The English Language and its Early Literature" (Gilmore) 565
"Darwinism and other Essays" (Fiske) 565
"Shell Mounds of Omari" (Morse) 566
"Fuel, its Combustion and Economy" (Clark) 566
"Units and Physical Constants" (Everett) 566
"Solar Light and Heat" (Allen) 567
"First Book of Qualitative Chemistry" (Prescott) 567
"Electro-Metallurgy" (Watt) 567
"Ceremonial Institutions" (Spencer) 698
"Theory of Political Economy" (Jevons) 699
"The Chemistry of Common Life" (Johnston) 701
"Astronomy for Schools and Colleges" (Newcomb and Holden) 702
"Progress and Poverty" (George) 702
"Lectures and Essays" (Clifford) 703
"An Essay on the Bible Narrative of Creation" (Grote) 705
"Triassic Formation of New Jersey" (Russell) 707
"Erasmus Darwin" (Krause) 707
"Eighth, Ninth, and Tenth Annual Reports of the Geological Survey of Indiana" (Cox) 708
"Modern Meteorology" 708
"The Great Fur Land" (Robinson) 708

Books noticed: PAGE
"The Berea Sandstone of Ohio" (Orton) 709
"The Crayfish" (Huxley) 850
"The Refutation of Darwinism" (O'Neill) 851
"Geological and Natural History Survey of Minnesota" (Winchell) .. 851
"The Kansas Review" 851
"The Californian" 851
"Zoölogy for Students and General Readers" (Packard) 852
"Problems of Life and Mind" (Lewes) 852
"The Younger Edda" (Anderson) 852
"Elementary Lessons on Sound" (Stone) 852
"Dictionary of German Terms used in Medicine" (Cotter) 853
"Theology and Mythology" (O'Donoghue) 853
"Popular Romances of the Middle Ages" (Cox and Jones) 853
"The American Entomologist" (Riley and Fuller) 853
"American Monthly Microscopical Journal" (Hitchcock) 853
"Economics of Industry" (Marshall) 853
"On the Native Iron of Greenland" (Smith) 854
"The Development of the Human Race" (Steinach) 854
"Beer, and its Manufacture formerly and now" (Planitz) 854
"The Berkeley Quarterly" 855
"The Workshop Companion" 855
"Blowpipe Analysis" (Landauer) 855
"United States Commission of Fish and Fisheries" 855
"Guides for Science-Teaching" 855
Literary Notes 850
Bigelow, W. S., Letter from 842
Bleaching Preparation, New 861
Brain-Cells, Education of 200
Brain, Size of, and Size of Body 872
Brain-Texture and Mental Make-up 143
Buckland, Frank 318
Buell, Charles J., Letter from 842
Burials, Premature 889
Butter-making, Improvements in 571

Canal Routes, Interoceanic 380
Cannibals, South African 283
Carpenter, Professor William B 614
Casualties, Railroad 413
Cattle, The Wild, of Great Britain 138
Celluloid, Composition and Uses of 859
Century-Plant, A Precocious 575
Chandler, Dr. Charles F., Sketch of. (Portrait.) 833
Chesapeake Laboratory, Work at the 570
Chinese, Morality among the 270
Chromatics, Rood's—A Misleading Criticism 274
Circulating Libraries and Contagious Disease 138
Colorado, Southern, Prehistoric Ruins in 666
Coloring Matters, New 575
Color-Sense, Education of the 425

PAGE
Commerce, Removing the Barriers of 416
Conant on International Copyright 697
Conant, William C 653
Cork, Ancient Uses of 429
Correspondence 266, 408, 554, 693, 842
Crayfish, The. (Illustrated.) 789
Criminal Law, Origin of 433
Criminal Law, The Origin of 842
Croll's "Climate and Time" 810
Crookes, William 13, 157
Curious Ways of getting Food. (Illustrated.) 770

Dalby, W. B 197
Daly, Charles P 478
Data of Ethics, Reception of the 408
Daylight in the Schoolroom 517
Death of Professor B. F. Mudge 569
Detective, A Scientific 141
Diamonds, Artificial 716
Diseases of Wild Animals 11
Diving, Improved Method of 711
Dolmens in Japan. (Illustrated.) 593
Dove, Heinrich Wilhelm, Sketch of. (Portrait.) 261

Eastern City, A Fabled 427
Eddy, William A. The Evolution of a New Sense 66
Editor's Table 121, 267, 408, 555, 695, 842
Educational Reform, Conditions of 849
Education for Guidance 559
Education of the Color-Sense 425
Education, Higher, of Women, Hygiene in the 519
Electricity and Vegetation 712
Electric Light, Distribution of the 284
Electric Light, Progress of the 570
Electrification, Expansion of Bodies by 574
Emergencies, Common Sense in 719
Enjoyment, The Duty of 640
Epidemics, Two Remarkable 286
Evolution, Fallacies of, A Reply to 101
Expansion of Bodies by Electrification 574
Experimental Legislation 754
Experiments in Punishment 431

Fairchild, Herman L 770
Far West, The Geology of the 568
Filtration, Ancient Methods of 495
Fish, A New Food 711
Fish, Animal Heat of 861
Fishes, Voice in 574
Fitch, Dr. Asa, Sketch of. (Portrait.) 116

PAGE
Food, Curious Ways of getting. (Illustrated.) 770
Forces, Wasted 408
Form, the Pleasure of Visual 780
Fourcy, Charles de 380
France, Apprentice-Schools in 285
Free Schools of America, The Early 663
Free-Will, Scientific Aspects of 745
Frost-Phenomena 842
Fuel, Water as 653

Gannett, Henry 666
Gas and the Electric Light 859
Geographical Science, The Beginnings of. (Illustrated.) 286
Geology of the Far West 568
George, Henry, On the Study of Political Economy 601
Glaciers, Experimental 860
Granville, J. Mortimer 200
Great Britain, The Wild Cattle of 138
Green Mountains, Age of the 858
Green, Nelson W 71
Grote, A. R., Letter from 266
Gypsies, Origin of the 540

Hanoverian Village Life 407
Harmony, Modern, Imperfections of 508
Hay, Dr. George, Letter from 694
Hemp-Plant, Intoxicating Properties of the 719
Herrings 427
Hoffmann, Frederick, Sketch of Dove 261
Honeycomb, a Living 824
Honey-making in the United States 142
Hopkins, J. H 798
Horses, Many-toed. (Illustrated.) 258
Household Pet, A Roguish. (Illustrated.) 318
Hygiene in the Higher Education of Women 518

Ice, Age of 554, 693
Ideas, The Association of. (Illustrated.) 577
Imperfections of Modern Harmony 508
Improvements in Butter-making 571
Intellectual Straining in Authorship 98
Intemperance in Study 645
International Copyright, Conant on 697
Interoceanic Canal Question, Some Features of the 842
Iron-making, Petroleum in 287
Iron, Passivity of 719
International Weather-Service, The. (Illustrated.) 289
Interoceanic Canal Routes. (Illustrated.) 380

Jackson, George A 236
James, William 577

PAGE
Japan, Dolmens in. (Illustrated.) 593
Javal, M., On Daylight in the Schoolroom 517
Jevons, Professor W. Stanley 754
Jupiter, What is He doing? (Illustrated.) 737

Kindergartens, Arsenic in 694
Knowledge, First-hand and Second-hand 197

Langley, S. P., Recent Progress of Solar Physics 1
Lankester, Professor E. Ray 789
Learning to write 795
Le Conte, John, Mars and his Moons 82
Le Conte, Joseph, The Genesis of Sex 167
Leffingwell, Dr. A. J 745
Legislation, Experimental 754
Leidy, Professor Joseph 612
"Let well enough alone" 695
Libraries, Circulating, and Contagious Disease 138
Lightning-Rod, Investigating the 863
Lindsay, W. Lauder 346
Literary Notices 125, 277, 417, 561, 698, 850
Lubbock, On Science in the Primary Schools 429
Luminous Power, Distribution of, in the Sun's Rays 137
Lungren, C. M., Progress and Poverty 721
Lyford, M., Letter from 693
Lyons, Lieutenant T. A 35, 179

Mackay, G. Eric 389
Maclagan, Dr. T. J., On Typhoid Fever 460
Man, On the Antiquity of 140, 572
Many-toed Horses. (Illustrated.) 258
Maps and Map-making before Mercator. (Illustrated.) 478
Mars and his Moons 82
Marsh, O. C 219, 363
Mason, R. O 330
Matamata, The. (Illustrated.) 684
Matter, Radiant. (Illustrated.) 13, 157
Maury, Professor T. B., International Weather-Service. (Illustrated.) 289
McGee, W. J 810
Meteoric Display, An Expected 247
Meteorology, Ocean. (Illustrated.) 35, 179
Mill, John Stuart 25, 311, 501
Minerals, Action of Organic Acids on 710
Monkey, Intelligence of a Pet 714
Moral Sense in the Lower Animals 346
Morals, Goldwin Smith on 267
Morse, Professor E. S 593
Mudge, B. F., Death of 569

Nature, The Force behind 614
Nelson, E 337

PAGE
Niger, Source of the 860
Nordenskjöld, What He has done 137
Nordhoff, Walter 467
Norton, H. B., Letter from 554
Notes 143, 287, 432, 576, 720, 864

Observations, Anthropometric 431
Ocean Meteorology. (Illustrated.) 35, 179
Oregon, Salmon Industries of 573
Origin of Criminal Law 433
Origin of the Gypsies 540

Paleontological Discovery, History and Methods of 219, 263
Pasture, Sheep poisoned at 575
Pearce, S. Austen 508
Perrier, Edmond 625
Petroleum in Iron-making 287
Petroleum for Steam-making 136
Phenomenon, Interesting Luminous 554
Philosophy, Mythologic 56
Phosphorescence, Vegetable 804
Phylloxera, Applications for 718
Physiology, The Study of 43
Plants, Agency of, in Earth-building 713
Plants, Assimilative Power of 142
Plants, The Textile, of the World 831
Platinum, Experiments with 134
Political Economy, Study of 601
Popular Miscellany 134, 283, 425, 568, 710, 858
Population of Africa 426
Powell, J. W., Mythologic Philosophy 56
Precocity, Cases of Remarkable 428
Prehistoric Ruins in Southern Colorado 666
Premature Burials 389
Prescott, Ellen 804
Preservative Process, A New 717
Proctor, Richard A., Expected Meteoric Display 247
Progress and Poverty 721
Progress of the Electric Light 570
Publications Received 133, 282, 425, 567, 709, 856
Punishment, Experiments in 431
Punishment, Vengeance in 555
Pye-Smith, P. H., The Study of Physiology 43

Rabies, Transmissibility of Human 712
Radiant Matter 18, 157
Railroad Casualties 418
Rhine, Alice H 663
Records, Prehistoric 545
Respecting Rubbish 97

PAGE
Ritter, Carl, Sketch of. (Portrait.) 689
River-Beds, The Old, of Middle California 858
Romanes, George J. 101

Salmon Industries of Oregon 573
Saporta's World of Plants before the Appearance of Man. (Illustrated.) .. 446
Sargassum. Does it vegetate in the Open Sea? 573
Sauvage, E. 684
Schools, Athletics in 677
Schroeder, Lieutenant Seaton 530
Science in the Primary Schools 429
Scientific Teaching in the Colleges 556
Scorpion, Suicide of the 712
Seamen, Color-Blindness of 285
Searle, Arthur 673
Seely, G. B., Letter from 554
Sense, A New, The Evolution of 66
Sex, The Genesis of 167
Sheep, poisoned at Pasture 575
Silliman, Benjamin, Sketch of. (Portrait.) 550
Skinner, Joseph J 397
Slack, H. J 737
Snakes, How they shed their Skins 710
Social Distinctions, Traditional Origin of 430
Solar Appendages 121
Solar Physics, Recent Progress of 1
Sounds, Discrimination and Memory of 428
Spies, Concerning Honors to 122
Spiritualism, Middle-Age 354
Springs and Wells, Overflow of. (Illustrated.) 71, 266, 397
Stammering and its Causes 863
Stars, The Immensity of the 140
Stoves, Ventilating 124
Study, Intemperance in 645
Suicide, A Consideration of 798
Sully, James 780
Sun-Spots and Rainfall 861

Tea-drinking, Effects of Excessive 862
Teeth, Effects of Tobacco on the 137
Telescope, Most Powerful in Existence 337
Theologian, A Young, Letter from 693
Thresher-Shark, Habits of the 139
Tobacco-Pipe, Antiquity of the 862
Tobacco-Smoking, Parkes on 718
Traditional Origin of Social D nctions 430
Trowbridge, J. T., Letter from 266
Tuke, D. Hack 645
Tylor, E. B., Recent Anthropology 145
Typhoid Fever, how conveyed 460

PAGE
Upper Air, Proportion of Oxygen in..... 575

Vaccination in New York..... 330
Vaile, E. O., Early Methods in Arithmetic..... 204
Vaughan, Professor Daniel, The Works of..... 125
Vegetable Phosphorescence..... 804
Vengeance in Punishment..... 555
Vessels, Raising Sunken..... 287
Vilain, Jean..... 11
Village Life, Hanoverian..... 467
Voice in Fishes..... 574

Wahl, William H..... 408
Ward's Natural Science Establishment..... 612
Water as Fuel..... 653
Waves, Stilling the, with Oil..... 136
Weather-Service, The International. (Illustrated.)..... 289
What is Jupiter doing? (Illustrated.)..... 737
Wild Animals, Diseases of..... 11
Windows, Stained..... 141
World of Plants before the Appearance of Man..... 446

Zoölogical Work at the Chesapeake Laboratory..... 570

END OF VOL. XVI.